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Construction Engineering Research Laboratory

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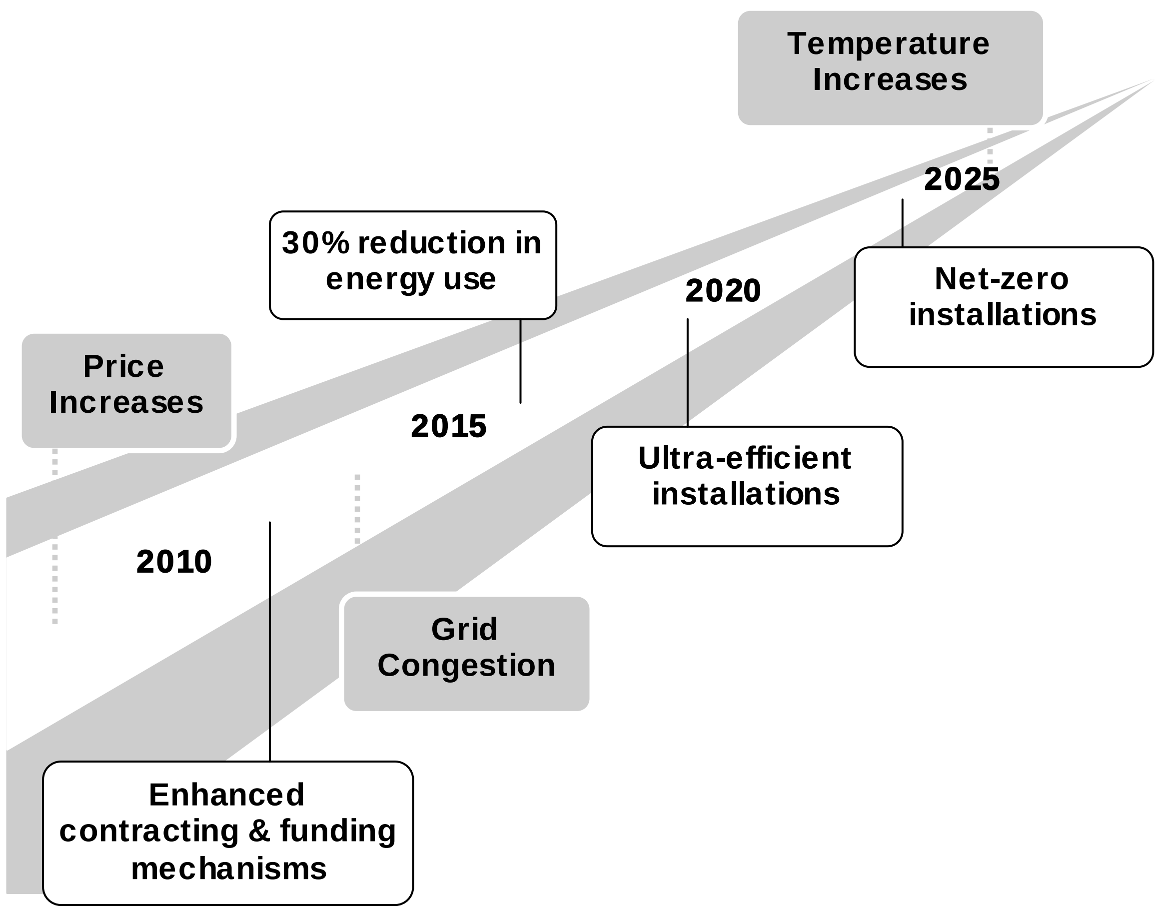
Center for the Advancement of Sustainability Innovations (CASI)

Energy Security

Emerging Challenges and Opportunities

Tarek Abdallah, Steven Cary, Michael Case, William Goran, Joshua Harris, Kevin Hern, Franklin Holcomb, Jordan Hudak, Steven Kenney, James Miller, and Natalie Myers

August 2010



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Abstract: Over the past decade, the U.S. Army has invested significant resources to ensure sufficient and sustainable supplies of energy, which is essential to mission performance. Many forward-looking energy projects are ongoing today as a result of this investment. To continue this success, a team of energy experts (composed of energy, engineering, and program management experts from U.S. Army Corps of Engineers [USACE], Assistant Chief of Staff for Installation Management [ACSIM], Installation Management Command [IMCOM], U.S. Air Force Academy, and private consultants) was formed to take a broad, strategic, and forward-minded look at evolving conditions and to explore the investments that are most critical to address energy security. The analysis looked at the technologies and policies driving future energy production, conservation, and security. The team then explored two hypothetical situations to illustrate possible outcomes from different courses of action. These scenarios included: (1) loss of the electrical power grid, and (2) loss of petroleum products, such as natural gas and liquid fuels. The result was a set of system-wide actions that IMCOM may choose to implement to improve energy security.

Executive Summary

This report identifies system-wide actions that IMCOM can implement to enhance energy security. Over the past decade, the U.S. Army has invested significant resources to ensure sufficient and sustainable supplies of energy, which is essential to mission performance. Many forward-looking energy projects are ongoing today. To continue this success, a team of energy experts (composed of energy, engineering, and program management experts from USACE, ACSIM, IMCOM, and private consultants) was formed to take a broad, strategic, and forward-minded look at evolving conditions and to explore the investments that are most critical to address energy security. The analysis looked at the technologies and policies driving future energy production, conservation, and security. The team then explored two hypothetical situations to illustrate possible outcomes from different courses of action. These scenarios included: (1) loss of the electrical power grid, and (2) loss of petroleum products, such as natural gas and liquid fuels. The resulting set of recommended actions (policy and procurement) follows. Although some of the recommendations below are already in the process of being implemented, this list represents a portfolio of actions that IMCOM may choose to consider.

Recommended actions within the near term (2010-2015)

- Radically improve facility energy efficiency (p 37).
- Plan for distributed power (i.e., “smart” and “micro” grids) (p 37).
- Adopt open source/open standard network security protocols through NIST and the DOE (p 38).
- Evaluate installation energy projects by clustered supply/load analysis (p 38).
- Exercise energy security capabilities (p 38).
- Increase involvement of energy program managers in Defense and Army Critical Infrastructure Programs (p 38).
- Prioritize installations for energy security projects (p 39).
- Establish a central repository of energy infrastructure data (p 39).
- Develop new investment funding strategies (p 39).
- Establish a team of utility contracting experts to assist installations (p 39).
- Properly staff and train personnel who manage utility contracts and utility sales (p 39).

- Remain competitive in terms of employee compensation (p 39).
- Foster partnerships between Federal agencies, local utilities, and financial institutions (p 40).

Recommended actions within the medium term (2015-2025)

- Establish a contractor certification/qualification program for ultra-efficient facilities (p 40).
- Adopt a regional approach to energy security planning (p 40).
- Establish standardized analytical tools (p 40).
- Conduct an installation scale nuclear power generation demonstration (p 40).
- Pursue enhanced contracting mechanisms for energy security (p 40).
- Establish an Energy Security Enhancement Fund (p 41).

Recommended actions within the long term (2025 +)

- Develop an "Islands of Stability" concept for installations (p 41).
- Seek more flexible cost-sharing options (p 41).
- Work with industry to develop, test, and field "evolving" systems (p 41).

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Preface

This study was conducted for the U.S. Army Installation Management Command (IMCOM) under Project, "Systematic Research/Scanning Support to IMCOM," via Military Interdepartmental Purchase Request (MIPR) MIPR9CERDC1049. The technical monitor(s) were Douglas Warnock and Matthew Barden, IMCOM.

The work was managed and executed by the Engineering Processes (CF-N) and Energy (CF-E) Branches of the Facilities Division (CF), Construction Engineering Research Laboratory (CERL). The CERL principal investigator was Dr. Michael Case. Appreciation is owed to Karen Baker and Scott McCain. Donald K. Hicks is Chief, CEERD-CF-N; Franklin H. Holcomb is Chief, CEERD-CF-E; and L. Michael Golish is Chief, CEERD-CF. The associated Technical Director was Martin Savoie, CEERD-CV-T. The director of the Center for Advancement of Sustainability Innovations (CASI) is William D. Goran. The Deputy Director of ERDC-CERL is Dr. Kirankumar Topudurti and the Director is Dr. Ilker Adiguzel.

CERL is an element of the U.S. Army Engineer Research and Development Center (ERDC), U.S. Army Corps of Engineers. The Commander and Executive Director of ERDC is COL Gary E. Johnston, and the Director of ERDC is Dr. James R. Houston.

1 Introduction

Background

The topic of energy security has become an important policy focus for the Department of Defense, the Army, and installations over the past decade. In addition to the recently released (October 2009) *Executive Order 13514* (EO13514), policy drivers such as the *Army Energy Strategy*, *Executive Order 13423* (EO13423) and *Army Energy Security Implementation Strategy* (AESIS) reflect legislative drivers such as the *Energy Policy Act of 2005* (EPACT 2005), the *Energy Independence and Security Act of 2007* (EISA 2007). The impetus for improved energy security is clear. Less clear is how to translate broad policy goals into concrete and systemic actions that can be implemented across IMCOM to ensure achievement of these goals.

Objectives

This objective of this IMCOM Futures work was to identify system-wide actions that IMCOM may choose to implement to improve energy security.

Approach

This work was accomplished in the following steps:

1. The meaning of energy security in accordance with policy was determined.
2. A wealth of ongoing energy efforts were reviewed—leading to the presentation of emerging technology and policy options.
3. Challenging energy security scenarios were discussed with an analysis of likely outcomes under different system-wide strategies. This built from ongoing efforts to take a longer, more strategic view of energy.
4. Finally, a set of recommended actions were compiled for consideration.

Mode of technology transfer

This report will be made accessible through the World Wide Web (WWW) at URL: http://www.cecer.army.mil

2 Energy Security

The Army Energy and Water Campaign Plan for Installations defines energy security as:

> the capacity to avoid adverse impact of energy disruptions caused either by natural, accidental or intentional events affecting energy and utility supply and distribution systems. Increasing energy security leads to improved reliability. Energy security programs take a different perspective than conventional energy management programs. Whereas energy management programs typically reduce energy consumption and cost, in most cases energy security is viewed as a cost obligation rather than cost avoidance. Cost avoidance or economic benefits of increased energy security are not easily quantified as we typically view baseline conditions as uninterrupted and reliable utility service. (HQDA 2007)

The *Army Energy Security Implementation Strategy* (AESIS) identifies five core characteristics that define the energy security necessary to complete the full range of Army missions: surety, survivability, supply, sufficiency, and sustainability (SEC and DASA E&P 2009). The AESIS expands on its definition to identify five Army Energy Security Goals:

1. Reduced energy consumption
2. Increased energy efficiency across platforms and facilities
3. Increased use of renewable/alternative energy
4. Assured access to sufficient energy supplies
5. Reduced adverse impacts on the environment.

These goals reflect a posture that uninterrupted, reliable supply depends on effective management. Energy security is concerned with the ability to support the mission during an extended period of interruption (most notably 1 year) regardless of the source of the problem. Also, a goal of secure energy differs from a traditional reliability goal in that it recognizes that various state and non-state actors may be actively seeking to disrupt energy supplies. These principles are shaping installation actions, where a number of indirect steps to improve the energy security of installations have already been undertaken. Examples include energy conservation retrofits, improvements to the energy performance of new facilities, pro-

curement of electric vehicles, and installation of various types of renewable energy generation projects (wind, photovoltaic, biomass, geothermal, etc.). This report is informed by knowledge of those projects, but seeks to address energy security from an enterprise level.

At the enterprise level, energy security involves managing operation processes effectively, making more efficient use of energy to avoid shortages, taking steps to secure existing energy sources, and seeking new alternative energy sources. The primary challenge for addressing energy security from an enterprise-wide perspective is the lack of a single decision maker armed with the authority and funding to alter the current landscape. Moreover, rapidly evolving technologies and opportunities to help address challenges complicate the issue further. New technologies are introducing new threats (such as cyber threats enabled by smart grid enhancements), vulnerabilities (security holes in new software formats), and risks (the kind of information accessed by an attacker). Many brilliant minds are working on understanding the future of energy. But what are the most insightful forecasts and useful scenarios on the future? The featured technologies, policies, and scenarios within the proceeding sections begin to answer that question.

3 Technology

Emerging renewable energy technology could play a key role in improving energy security for Army Installations. Many of today's policy initiatives adopt a "shaping" posture by investing in technologies such as solar thermal energy and photovoltaics even though they are not yet commercially viable. The expectation is that as these technologies mature and traditional sources of energy become more expensive, the newer technologies will become viable. This report discusses a number of emerging technologies that policy-makers should be aware of.

Energy conservation measures

Drivers and technology

The term "negawatt" was coined by Amory Lovins to describe the principle that it is less expensive to use energy efficiently than to create more of it (Fickett, Gellings, and Lovins 1990). The concept focuses on the practice of decreasing the quantity of energy used and aligns with the AESIS goal to improve the efficiency with which facilities use energy. In fact, this may be the most important strategy to achieving energy security. Energy conservation reduces the energy consumption and energy demand per capita and thus offsets some of the growth in energy supply needed to keep up with population and mission expansion. This reduces the rise in energy costs, and can reduce the need for new power plants and energy imports. Reduced energy demand can provide more flexibility in choosing the most preferred methods of energy production.

Today, EPACT 2005 requires new buildings to be 30 percent more efficient than ASHRAE 90.1-2004. EISA 2007 requires a 100 percent reduction in fossil fuel-generated usage by 2030 (with intermediate goals) for new and refurbished facilities. The Army's policy goal is to have 25 zero-net-energy installations by 2025, and Executive Order (EO) 13514 challenges all Federal buildings designed after 2020 to achieve zero-net-energy. Even if these goals are achieved, one must keep in mind that 75 to 80 percent of facilities that will exist in 2030 exist today. More efficient new facilities will have an important, but small effect on overall facility demand. It may not be feasible to achieve current legislation and policy

goals without dramatic improving energy conservation measures for existing facilities.

The term "Energy Conservation Measures (ECMs)" is a generic term used to describe technologies that can be applied to new or existing facilities to improve their energy efficiency. Examples include advance insulation materials, airtight construction, advanced windows (beyond Energy Star), air-to-air heat exchangers, passive solar, thermal mass, and others. Based on world-wide research on ECMs, it is now economically feasible in most North American climate regions to exceed ASHRAE 90.1 requirements by 70 percent rather than 30 percent using ECM practices. Going beyond 70 percent is generally feasible using facility clustering approaches. Just a few example ECM technologies appear below. Unfortunately, many ECM that have been identified are not familiar to Energy Saving Performance Contracting (ESPC) vendors. Suppliers are often unwilling to risk installing unfamiliar systems or lack the documentation on savings, and are thus unable to secure the necessary funding. One area that should be explored is having U.S. Department of Energy /Federal Energy Management Program (DOE/FEMP) support certain technologies that represent good enterprise solutions; and strengthening a working relationship with the Army's Venture Capital Investment Arm and OnPoint Technologies to leverage emerging energy technologies.

Conservation pros/cons and implications

Demand Expectations:	Efficiency cost is reducing over time while energy costs are increasing; Stronger demand for conservation expected, with increased policy requirements.
Advantages:	Carbon neutral; Continually available 24/7.
Disadvantages:	Infrastructure retrofits (i.e., appliances, plugs, and meters); Societal behavioral changes take time.
Environmental Impact:	Preserve natural resources; Disposal of old infrastructure.
Technology Issues:	Somewhat of a market failure, although cost decreasing.
Investment Needs:	Needs more emphasis as national strategy.
Investment Strategy:	Continue using prescriptive requirements to capture the first 20 to 30% savings above current codes. Demonstrate what it takes to get 50% efficiency in near term. Research what it takes to get 70+% savings in longer term. Make performance visible and understandable (e.g., you cannot manage what you cannot or do not measure). Energy performance labeling is in EISA 2007 and needs to be highlighted and implemented. Gain a more complete understanding on how buildings actually operate—not just how they are designed and simulated.

Example technology

The technology discussions below begin to frame the classic question: "Should I buy now or wait for the next improvement?" The answer is to buy all that you can afford now. Always purchase all you can in the passive technologies category (windows, insulation, etc.) due to their lower operations and maintenance (O&M) costs and since most of them are very difficult or expensive to change later. This also avoids the purchase of higher cost active technologies (heating, ventilating, and air-conditioning [HVAC,] boilers, photovoltaic (PV), etc.) with shorter replacement times and higher O&M costs. If you are going to wait on the technology curve you would do this in the active technology category. These items normally have a shorter life and may have to be replaced several times during the buildings life. The windows and insulation could last the entire life of the building. Some important general principles highlighted by energy engineers are:

- Minimize exterior window areas; use the best window you can buy with insulating low-e glass and shade it. Add all of the insulation that is physically possible in the wall and roof structures and reduce/eliminate thermal bridging in all exterior components.
- Avoid glazing facing west; this helps eliminate peak loads, which reduces the cost and size of the HVAC system.
- Design to use daylighting with daylighting controls on lighting systems.
- Design and construct buildings to be as air tight as possible, the Army is starting this with the 0.25cfm/sq ft at 75pa (i.e., "seal airtight and ventilate right").
- Commission buildings and systems.
- Seal all the ductwork and their connections using mastic.
- Design HVAC system to bring in the correct ventilation that matches the occupancy and schedules. The preference would be to use on demand ventilation using CO_2 monitoring. Bringing in the right amount of ventilation is crucial — not too much and not too little.
- Keep indoor air dewpoint low to avoid mold and mildew issues, and also to augment building durability. Another benefit of maintaining a low indoor dewpoint is that it enables occupants to comfortably tolerate a wider temperature variation without over-cooling the building.
- Invest in constant commissioning for buildings to provide high returns on the energy investment and better comfort and control.

Insulation technology

Mineral wool/polystyrene provides a thermal conductivity of 0.030–0.035 compared to “regular” 0.040 W/mK. Graphite embedded Expanded Polystyrene (EPS) reduces radiant heat transfer and reduces thermal conductivity by 20 percent. Vacuum insulation panels provide an insulation value of three to seven times that of equivalent thickness of other insulation materials, such as rigid foam boards, foam beads, or fiber blankets. Materials to insulate are of various types and effectiveness. Insulation is one of the lowest cost options for improving a building’s energy efficiency (Table 1).

Lighting technology

Spectrally enhanced lighting is a lighting design technique that can save 20 percent more energy than commonly used T8/electronic ballasted fluorescent lighting systems. Properly designed systems can achieve 50 percent savings over T12 and magnetically ballasted lighting systems. These savings are achieved by using naturally occurring visual efficiencies gained through the use of lighting with a color spectrum more like daylight than most commonly used light sources, which are more yellow in appearance than spectrally enhanced lighting. Visual benefits are that the human eye perceives objects under the enhanced spectrum as brighter and sharper than under “normal” fluorescent lighting at the same footcandle level. These benefits are a natural result of the eye’s response to shifting the color of light to include more blue in the spectrum.

Table 1. Insulation cost-benefit analysis (Zhivov 1990).

Innovative System	Average costs for the saved energy in 20 years ($/kWh)
Higher insulation thickness*	0.12
Graphite embedded EPS†	0.18
High performance plaster systems†	0.94
Vacuum insulation systems†	0.30
Light wedges‡	0.18
Transparent insulation material†	0.52
Solar walls'	0.04

*Compared to thickness according to requirements
†Compared to conventional insulation material of same thickness
‡Electrical lighting savings
'Used as preheating of ventilation systems

Shifting the color in fluorescent lamps to make a more Spectrally Enhanced light source is easily accomplished through mixing the phosphors of the lamps to achieve a higher Correlated Color Temperatures (CCTs) and Color Rendering Index (CRI). These shifts generally result in a higher Scotopic to Photopic ratio, or S/P value, which is used in the mathematical formulae to evaluate the visual effects. For instance, a light source with a 5000K Correlated Color Temperature (CCT) and 82 Color Rendering Index (CRI) will have a higher S/P ratio than a 3500 CCT, 75 CRI fluorescent lamp, and will therefore provide better visual acuity under the conditions of equal measured lighting levels. Energy savings are obtained by using lamps that have a higher S/P ratio, and then determining the setting for the light levels that will result in equal visual acuity. For instance, if the visual benefit from the enhanced spectrum is 20 percent, the lighting levels could be reduced by 20 percent to obtain the same reading ability, which therefore results in a 20 percent savings in energy.

Spectrally enhanced lighting is a proven method for providing energy savings and there are no known negatives to installing this type of lighting in commercial office environments. The 5000K, 82 CRI fluorescent lamp is manufactured by all the major lamp manufacturers and is easily obtainable, generally at no additional cost over lamps that have otherwise the same specifications for wattage, life, and lumen output. For retrofits and new construction, the payback is immediate since the energy savings are 20 percent better than alternative methods and there is no increase in installed costs. The payback on replacing existing T12 systems is 1.4 years and on existing T8 systems ranges from 3 to 4 years.

Window technology

Commercially available advanced windows provide a U value of 0.0 to 0.13 (R value 7.1 to 11.1) compared to the standard, Energy Star, with a U value of 0.35 for the northern U.S. climate zone. The technology curve shown in Figure 1 indicates that installing and retrofitting R6 windows today is a smart investment. The benefits gained through technology for the next 10 to 20 years will not provide significantly better performance.

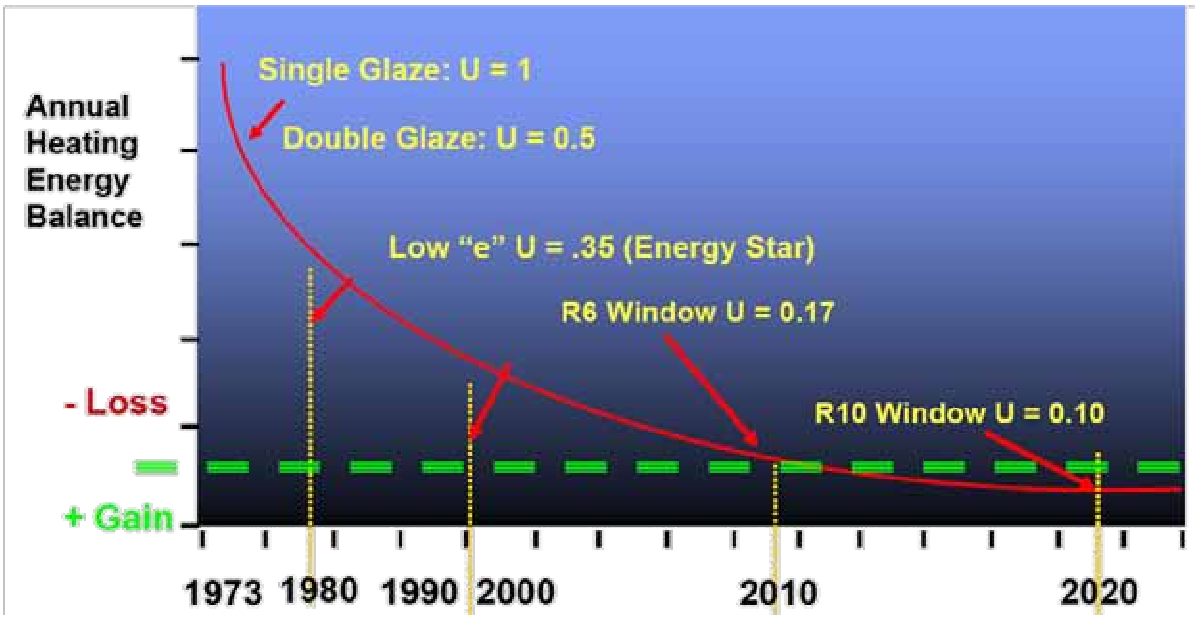


Figure 1. Advanced windows (Zhivov 2009).

Heating and cooling technology

Dedicated outdoor air systems (DOAS), when compared to the conventional all air HVAC system, result in lower first and operating costs, provide superior indoor air quality (IAQ) and thermal and acoustical comfort, reduce the hazard of a biological or chemical attack in the building, reduce the required plenum depth, and are easier to balance temperature and maintain equipment. Capillary radiant heating/cooling systems, as part of a DOAS, ensure that contaminants generated or released in one space are not distributed throughout the building by the HVAC system.

Solar thermal and heat recovery technology

Honeywell recently announced that its Genetron® R-245fa refrigerant is being used in an organic rankine cycle (ORC) to help homeowners generate electricity from the sun's heat while offsetting energy costs. A German firm uses the R-245fa refrigerant as the working fluid in a system that captures solar thermal energy to evaporate the refrigerant and drive a turbine to generate electricity. The unit is claimed to produce an electrical power output of 3.5kW, which is ideally suited to residential applications. Because no fuel is burned to create the electricity, the unit produces no carbon dioxide emissions. The remaining heat from the ORC can be used to

supply heating and hot water. The refrigerant is said to be non-flammable, non-ozone-depleting, and to have low toxicity.

The manufacturer of the ORC system specializes in development, production, and sale of ORC systems that convert low temperature heat into electricity. ORC technology comes in sizes up to 500KW to meet the needs of differing heat recovery opportunities. While the system described above may be too small to be of significant interest to the Army, ORC technology bears attention as it is further refined.

Grid technologies

Drivers and technology

The latest electrical industry's *Long-Term Reliability Assessment, 2008-2017* (NERC 2008) reports that the U.S. national energy grid is rapidly reaching its limitations. By 2017, much of the nation will have overstepped its recommended reserve margins and electricity prices are expected to increase by 50 percent (USDOE 2009). Our lights may remain on, but systemically, the risks associated with relying on an often overtaxed grid will grow in size, scale, and complexity. Additionally, cyber security threats are emerging on our nation's existing power grid, making DOD installations vulnerable to power disruptions through indirect attacks on the civilian power grid. As early as 2002, 70 percent of energy and power companies experienced a severe cyber-attack on their systems (USDOE 2009). A possible solution to our efficiency and security issues comes in the form of new distributed grid technologies, better known as "smart grids" and "microgrids." These technologies would allow installations the ability to operate their power distribution systems more efficiently, and would allow installations to isolate themselves from the national electrical grid and to operate using only on-installation power generation as needed.

Smart grid technology. In principle, a "smart grid" is the addition of a two-way communications system to the existing power grid along with sensors and management controls. It combines a traditional power distribution system with "smart" meters at points of use, sensors such as Phasor Measurement Units (PMUs) and Advanced Metering Infrastructure (AMI) meters throughout the transmission and distribution network, a two-way communications and control systems, and possibly a demand responsive pricing program with the local utility to realize the full benefits of reducing

loads, and therefore utility costs, during peak demand periods. With an overlay of digital technology, a smarter grid would incorporate:

- active participation by users
- multiple power generation and energy storage options throughout the grid, including renewable energy
- improved power quality
- optimized asset use and improved operating efficiency
- the ability to anticipate and detect disturbances and quickly recover in a self-healing manner
- resiliency to physical and non-physical attack, and natural disasters.

Construction of the National Smart Grid is the beginning, but by no means the end of the story. If the Smart Grid is built out to maturity, security experts say it may introduce both cyber-security and manpower concerns. While smart grid technology offers more layers of control, it will require additional management and built-in security, according to the U.S. Department of Energy's Electricity Advisory Committee (USDOE 2008) and the North American Electric Reliability Corp. (NERC 2008).

In 2009, President Barack Obama asked the U.S. Congress "to act without delay" to pass legislation that included doubling alternative energy production in the next 3 years, and building a National Smart Grid (Obama 2009). Moreover, the President's stimulus package calls for the installation of 40 million smart meters, allocating at least $4.5 billion for direct investment. According to a report from the Federal Energy Regulatory Commission in December 2008 (FERC 2008), advanced meters account for just 4.7 percent of all installed meters, though smart meter build-out is estimated to assume 20 percent of meters by 2030. On 13 April 2009, George W. Arnold was named the first National Coordinator for Smart Grid Interoperability (NIST 2009).

There are a number of frameworks for the modernized grid that can help the Army determine where to spend time and money. The Center for Smart Energy provides a useful overview. Today, IMCOM is installing meters to comply with Federal legislation, but does not have the ability to "analyze" the data.

Smart grid technology pros/cons and implications

High growth rate; Stimulus spending is expected to increase growth; National goal for adaption by 2020.

Carbon neutral; Increased grid control; Reduce/avoid peak hour pricing tariffs, Increased ability to detect and mitigate grid disturbances.

Increased access points for security threats; Infrastructure retrofits (i.e., appliances, sensors, and meters); Privacy and operational security concerns.

Balance time of energy use and availability; Increase use of renewable energy.

Security vulnerabilities; Infrastructure construction.

Agreed on standards are necessary for equipment and Information Technology (IT) construction.

Support smart grid prototypes on Army installations; Begin to address the integration of power and communication management (e.g., energy managers may need to acquire security clearances).

Microgrid technology. The microgrid concept goes further down the path of distributed power and load management. Conceptually, a microgrid is an integrated network of local power sources (e.g., renewables, hydropower, and cogeneration sources), a local power distribution system that connects to the centralized power grid, loads (e.g., barracks, dining facilities, motor-pools, and classroom facilities), and optional energy storage devices (e.g., batteries, capacitors, and fuel cells), with the following characteristics:

- the ability to operate as part of a centralized power grid, or as a self-sufficient "island," and the ability to seamlessly transition from one mode to the other
- collocation of power generation, energy storage, and power distribution with the point of use
- scalability
- improved power reliability and power quality
- the ability to operate with local and centralized control systems.

Microgrid technology pros/cons and implications

Demand Expectations:	High growth rate; Stimulus spending is expected to increase growth; National goal for adaption by 2020.
Advantages:	Carbon neutral; Increased grid control; Mitigate grid related vulnerabilities, Lower transport and dispersion (T&D) system losses; Local improvements to power quality; Incorporates flexible power generation and energy storage options
Disadvantages:	Infrastructure retrofits (i.e., additional controls, transfer switches, etc.); Increased access points for security threats.
Environmental Impact:	Balance time of energy use and availability; Increase use of renewable energy; Increase use of locally produced energy.
Technology Issues:	Security vulnerabilities; Infrastructure construction; Operator knowledge.
Investment Needs:	Agreed on standards are necessary for equipment and IT construction.
Investment Strategy:	Support micro-grid prototypes on Army installations; Begin to address the integration of local power networks and communication management.

The ideal situation for installations may be a combination of smart grid and microgrid technology, in effect creating a *smart microgrid* (Figure 2). Taking advantage of a smart grid's communications and control network, and a microgrid's local power generation, energy storage, and distribution, a smart microgrid would ensure the optimization and resiliency of the complete power distribution system. This would allow smoother integration with the National Smart Grid while giving installations the required control over their power systems. A system where a local utility would see an installation as "just another customer" with respect to total power demand or power output, but internal demand from specific facilities and power generated using on installation resources remains hidden from utility providers, may be the most appropriate.

A recent project at Fort Bragg serves as a positive demonstration of a smart microgrid. The modernized power grid at Fort Bragg is designed to save money, improve reliability, and provide a way to operate as an island during power failures, through retrofitting existing generators for centralized and remote control. To a large degree, standard equipment was used in the modernization of the grid with limited modifications (Resource Dynamics Corp. 2005).

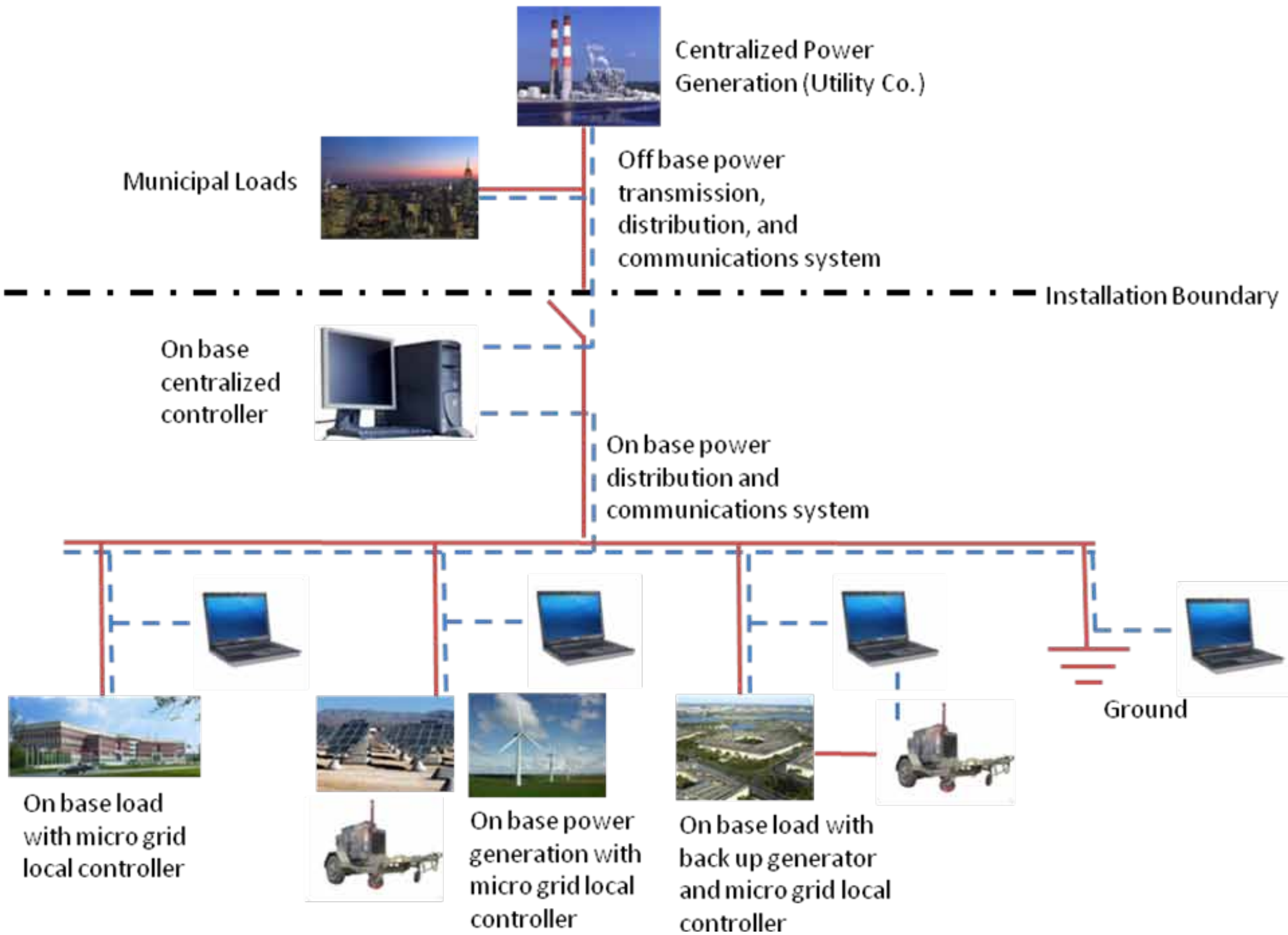


Figure 2. A smart microgrid.

Development of the Smart Grid is expected to occur at the grass roots level and grow into a more interconnected network at the national level with guidance and leadership from the Federal government. This requires that installations closely coordinate with their local and regional utility providers when modernizing their own electrical power distribution networks, and ensure they are coordinated with local efforts. Given that smart grid implementation is expected to begin at the local level and grow to the national level, a National Smart Grid implementation timeline has yet to be officially adopted by the Department of Energy. However, by combining the Smart Grid Maturity Model developed by IBM and seven utility companies, and later adopted by the DOE (USDOE 2009), with the strategic goals published by DOE in their 2003 report titled "Grid 2030: A National Vision for Electricity's Second 100 Years" (USDOE 2003), an approximate timeline for implementation of the National Smart Grid can be developed (Figure 3).

This timeline implies that, between 2010 and 2015, installations should be coordinating their implementation strategies for smart and microgrid modernization, and should begin negotiating demand responsive utility pricing schemes with their local utility providers. During this timeframe, it may also be appropriate for stakeholders to support the adoption of open source or open standard software, hardware, and security protocols. From 2015 to 2025, installations should plan on implementing their smart and micro-grid strategies in conjunction with local utility providers to provide "islands of stability."

Recommendations for implementation

Closer integration of power and communication management and policy will have an important effect on overall installation security as a more networked electrical power grid may be more vulnerable to a coordinated cyber-attack (Williams 2009). A number of network standards are being proposed for distributed grid technology through the DOE and the National Institute of Standards and Technology (NIST), but they may not meet Army standards for cyber-security. It will not be feasible to achieve current legislation and policy goals for microgrids without integration between DOE, Network Energy Technology Command (NETCOM), and USACE to address security implications posed by smart and micro grids up front.

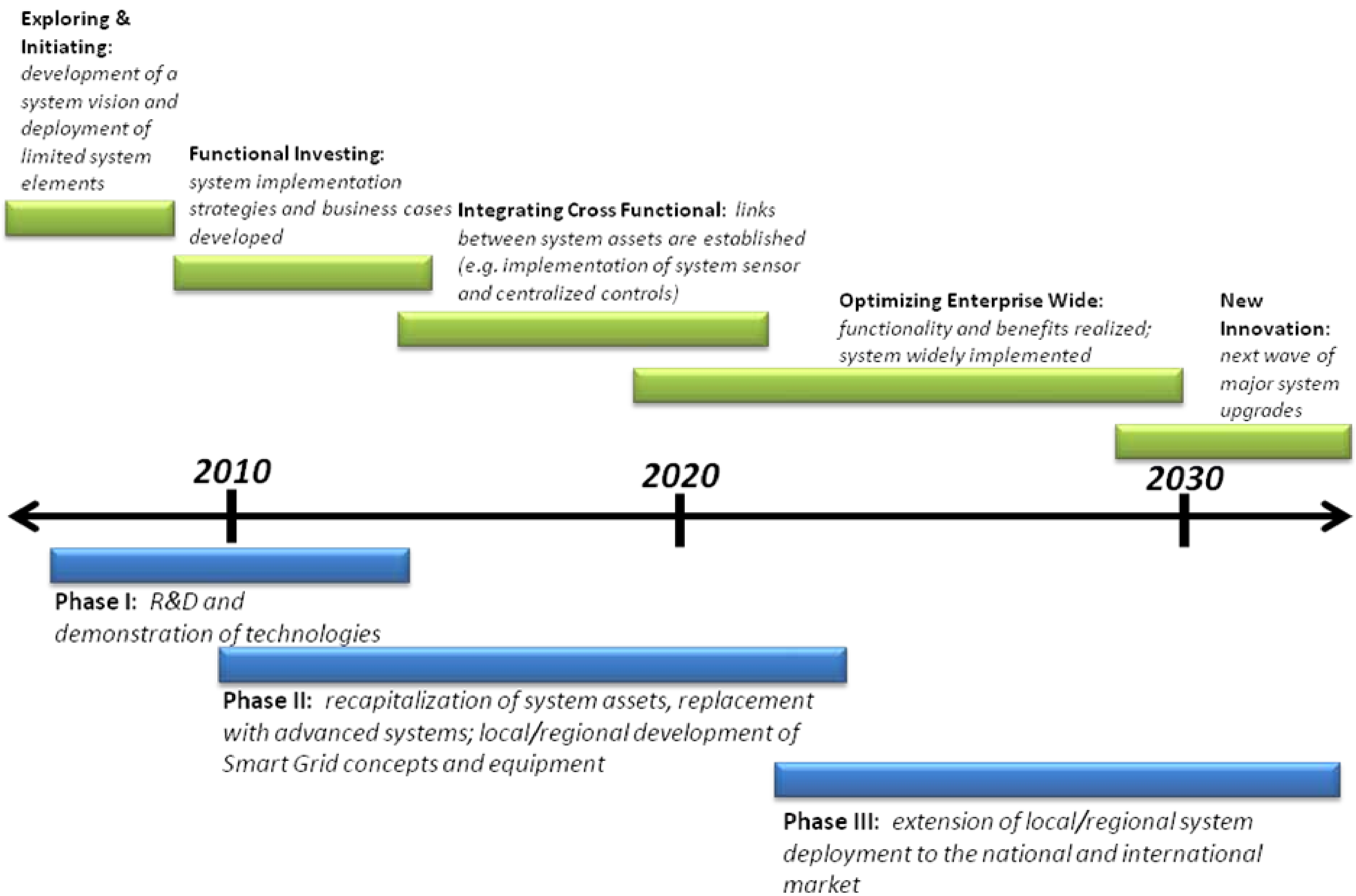


Figure 3. National Smart Grid implementation timeline.

To allow installations to receive the most benefit of smart microgrid technology, the following are recommended for implementation over the next 10 to 15 years:

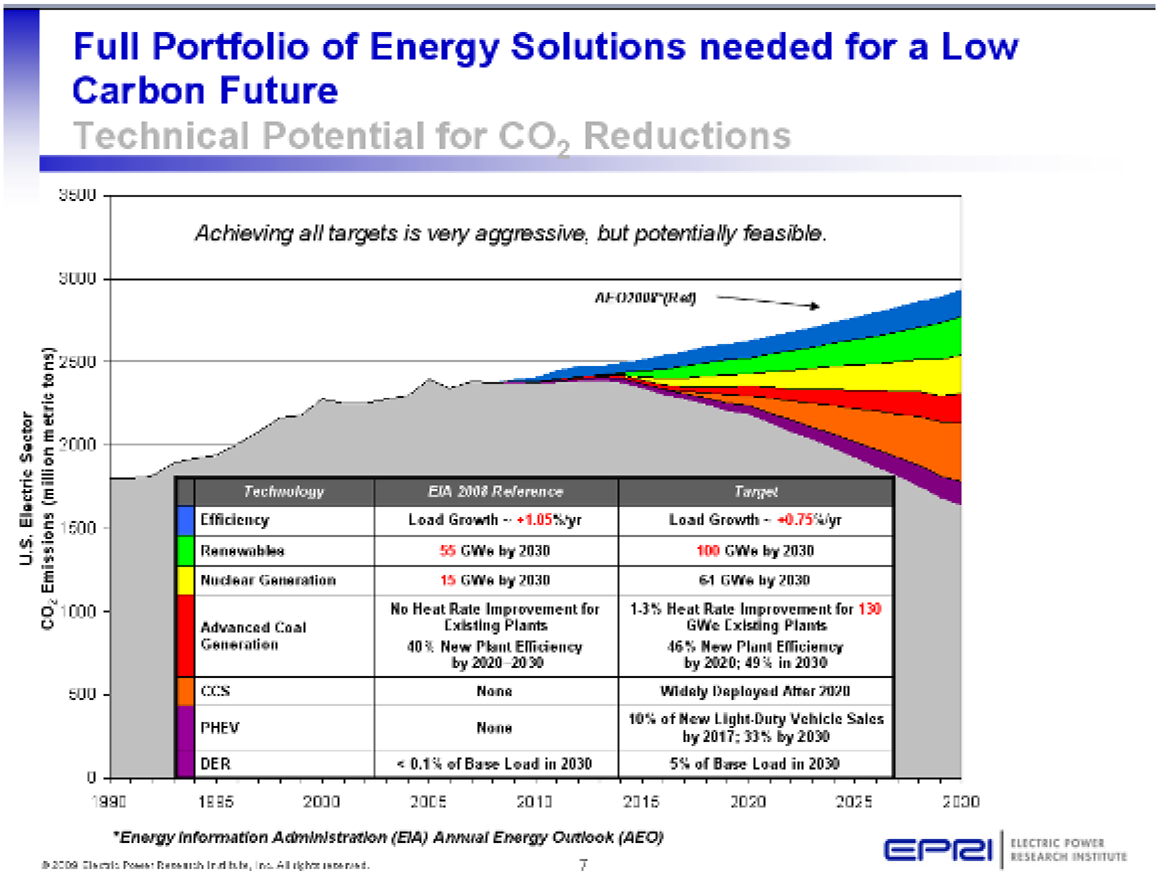
- adoption of open source/open standard network security protocols through NIST and the DOE
- placement of installation power control systems on a separate, secure communications network
- elimination of single points of failure by enabling local controllers to "step in" for central controllers or for each other when necessary
- masking of internal power usage and generation data from local utilities and external observers via central controllers
- analysis of the consequences of system attacks during system design
- automation of system recovery strategies to mitigate consequences of a successful attack, to include considerations of multiple points of failure from a coordinated attack and recovery with no communications among local and central controllers
- incorporation of physical security and surveillance into system access points
- negotiation of peak demand pricing agreements with utility providers
- continued support for DOD pilot projects and study of non-DOD projects.

Renewable and alternative energy sources

Drivers and technology

Approximately 9 percent of electricity in the United States is generated from renewable sources (EIA 2009). This is growing by 30 percent annually, backed by wide public support and strong corporate investment (Hala 2009). As oil prices continue to rise and the cost of alternatives continues to fall with further technical advances, it seems likely that carbon fuels will no longer be the main energy source in 2 to 3 decades. Figure 4 shows Energy Information Administration (EIA) data used to project the distribution of future sources given current targets (Rastler 2009).

Emissions of carbon dioxide by the U.S. electric generation sector could drop below 1990 levels by 2030 through the use of seven categories of technologies. Together, efficiency improvements and additional sources of renewable energy (at least for a while) nearly flatten out carbon dioxide emissions in the electricity sector if we can achieve these targets. Compared with the EIA forecast of 20 gigawatts of new nuclear capacity by 2030, the Electric Power Research Institute (EPRI) has set a target of 64 gigawatts of new nuclear power by then.



NOTE: CCS = carbon capture and sequestration;
PHEV = plug-in hybrid electric vehicle;
DER = distributed energy resources.

Figure 4. Carbon emission reduction responses.

The first new advanced light-water reactors would come on line in 2016. Creating 64 gigawatts of new capacity would require 40 to 45 new advanced light-water reactors by 2030. When new nuclear capacity is added to efficiency and renewables, the curve of carbon dioxide emission starts to bend downward. Reducing carbon dioxide emissions will require technological advances in the four key areas: (1) enabling efficiency, PHEVs, DER via the smart distribution grid; (2) enabling intermittent renewables via advanced transmission grids; (3) expanded advanced light-water reactor deployment; and (4) advanced coal plants with CO_2 capture and storage.

To leverage renewable energy alternatives, facilities are aggressively exploring enhanced use leases (EULs). Most recently (July 2009), the U.S. Army Corps of Engineers announced that it has selected Irwin Energy Security Partners LLC, a team comprised of Clark Enterprises and Acciona Solar Power, to develop, construct, and manage the largest solar power project proposed to date within the DOD, at Fort Irwin (USACE Baltimore District 2009). The Clark-Acciona proposal features concentrated solar

thermal and photovoltaic technology delivering up to 1000 megawatts of power generation while advancing the transformation of Fort Irwin's overall energy security. EULs make it common to consider energy projects facility by facility. However, technology advantages can often be achieved by considering a geographically grouped "cluster" of facilities with complementary load schedules and energy production capability. The following technology "pros/cons and implications" were drawn from several sources, including Techcast (2007), EIA (2009), U.S. Environmental Protection Agency (USEPA 1997), and ERDC/CERL (Westervelt and Fournier 2005).

Wind pros/cons and implications

Demand Expectations:	Fastest growing energy resource; Current market share is 3 to 5%; Year 2030 projected market share is 25%.
Advantages:	Carbon neutral; Renewable resource.
Disadvantages:	Limited sites in areas of high population density; Intermittent resource.
Environmental Impact:	Bird and bat kills; Noise; Visual pollution; Land consumption.
Technology Issues:	Turbines continue to increase in size and economies of scale.
Investment Needs:	Good wind sites are far from population centers.

Solar (PV and thermal) pros/cons and implications

Demand Expectations:	Continues to expand; Current market share is 1 to 2%; Year 2030 projected market share is 20%; By 2025, solar costs are projected to improve by 60%.
Advantages:	Carbon neutral; Renewable resource.
Disadvantages:	High cost; Still needs considerable research and development (R&D) and market penetration; Solar access required; Intermittent resource.
Environmental Impact:	Land consumption; Hazardous waste in production; Some deaths mostly associated with falls from roofs.
Technology Issues:	Photovoltaic too expensive; Efficiency must be higher and collector costs must be lower.
Investment Needs:	R&D in energy storage.

Geothermal pros/cons and implications

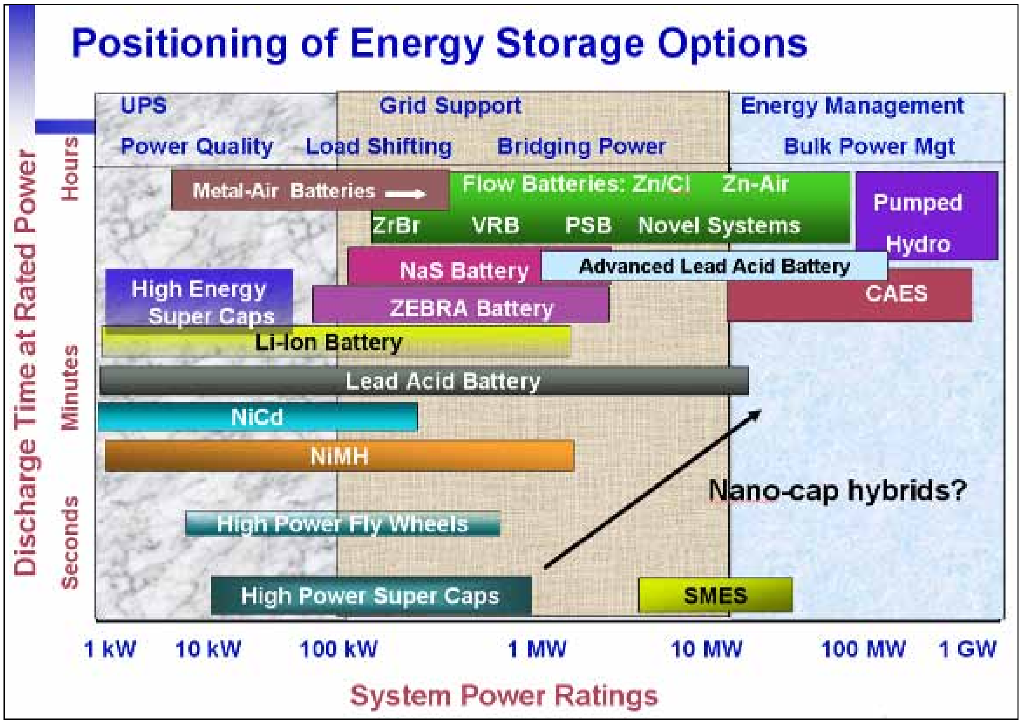
Demand Expectations:	Production expected to grow from 1% current market share to 10% by 2030; Will be developed where available (not a world or national market).
Advantages:	Carbon neutral; Renewable resource; Continually available 24/7.
Disadvantages:	Regional resource; Not generally available; Mostly in western United States
Environmental Impact:	Some sulfur emissions; Significantly less impact than fossil fuels.
Technology Issues:	Well developed; Source constrained.
Investment Needs:	R&D to increase available sites.

Waste to energy pros/cons and implications

Demand Expectations:	DOE projects low growth rate although state renewable portfolio requirements may spur growth. Current market share is 1% with up to 8% projections by 2030.
Advantages:	Carbon neutral; Renewable resource.
Disadvantages:	Should be used near where produced to avoid high shipping costs; Low specific energy density compared to fossil fuels.
Environmental Impact:	Direct combustion results in CO, NOx, and particulates; Harvesting and transportation have impacts depending on type and source.
Technology Issues:	Continued research on gasification and liquefaction.
Investment Needs:	R&D on gasification.

Energy storage pros/cons and implications

Demand Expectations:	Continues to expand in applications; Future positioning for smart grid demonstrations; Expected to be integrated with smart grids by 2015.
Advantages:	Carbon neutral; Renewable resource; Grid peak shaving; Outage and intermittent source (i.e., distributed photovoltaic systems) mitigation; Modular and scalable; Portable.
Disadvantages:	Relatively expensive; Still needs considerable R&D to maximize power and lifespan.
Environmental Impact:	Small substation footprint; Very low toxicity; Disposability or recyclability of hazardous material.
Technology Issues:	Continued research on energy density (cycle-life) and Charging/discharging capability; Require managed ambient air conditions.
Investment Needs:	R&D for increasing potential and capacity; Potential to support increased use of renewable energies.
Example Technology:	Figure 5 compares energy storage systems output vs. lifespan.



Source: Rastler (2009).

Figure 5. Positioning of energy storage options.

Nuclear power pros/cons and implications

Demand Expectations: Existing plants are being upgraded; Two to three new plants are in the planning stages; Demand could grow significantly if carbon dioxide production becomes regulated or taxed; Currently 19.5 percent of electric power in the United States is generated by nuclear power plants (USEPA 2004); EPACT2005 tax credits are expected to stimulate some nuclear bids.

Advantages: No air pollution; No Greenhouse Gas (GHG) emissions; Limited import dependence (just source fuel); High reliability; Lowest fuel costs; Least sensitive to fuel costs.

Disadvantages: High plant constructions costs; Extended construction times for new plants; Fuel cycle not closed; No spent fuel disposal method at this time; Great public fear and resistance to new facilities.

Environmental Impact: Power plants have large thermal signature; Waste disposal unresolved; Accidents could spread fission products over a large area leading to cancer deaths and unusable land areas.

Technology Issues: New, safe reactor designs; Waste disposal unresolved issue; New licensing process underway.

Investment Needs: Waste disposal unresolved; Closing the fuel cycle unresolved; R&D in breeder reactors and fusion power.

Example Technology: Hyperion Power Module (HPM) is a small-scale, modular power generation device that provides both thermal (70MWt) and/or electrical (25MWe) for 7 to 10 years. Each module costs $25 to $30 million and the first delivery date is 2013.

4 Policy Considerations

The DOD said in its 2008 report to Congress that it "is actively focused on initiatives to reduce energy demand, increase alternative sources of energy, and ensure the energy gets to where it is needed reliably and efficiently" (DOD 2008). Policy measures to increase energy security center on reducing dependence on any one source of imported energy, increasing the number of suppliers, exploiting native fossil fuel or renewable energy resources, and reducing overall demand through energy conservation and efficiency. These measures include the 2003 *Homeland Security Presidential Directive #7* (HSPD#7), the *Energy Policy Act of 2005* (EPAct 2005), the 2007 *Executive Order 13423 Strengthening Federal Environmental, Energy, and Transportation Management*, the *Energy Independence and Security Act (*EISA) of 2007 and the 2009 *Executive Order 13514 Federal Leadership in Environmental, Energy, and Economic Performance*. Each conceived as individual projects and each separately justified. The result is a series of decentralized or fragmented targets. Table 2 lists several mandated energy performance targets for all fixed installations.

The emerging strategic thinking of the *Army Strategy for the Environment*, the 2008 Defense Science Board (DSB) *Task Force on DOD Energy Strategy*, and the 2009 *Army Energy Security Implementation Strategy (*replaced the *Army Energy and Water Campaign Plan*) calls for a comprehensive systems approach to resource management. The battle cry is that our defense systems are dangerously oil dependent, wasteful, and weakened by a fragile electrical grid. The hope is for the security of the United States to be more organizationally coherent with strong regional and local partnerships—enabling a faster and more flexible response to issues such as acts of global or domestic terrorism, disaster resiliency, or environmental sustainability. Moreover, the vision of the Obama administration has been to create and manage a government that is more transparent, participatory, and collaborative—presaging a more centralized and coordinated approach to dealing with core security issues.

Table 2. Energy directives for fixed installations.*

Directive Topic	Energy Performance Target	Source
Installations energy use	Reduce by 3% per year from FY 2008. 2015 ending in a 30% reduction in energy intensity by 2015 from 2003 baseline.	EO13423 & EISA 2007
Electricity consumption from renewable sources	Must be 3% in FY 2009-2009, 5% in FY 1010-2012, and 7.5% in FY2012 and beyond.	EPAct 2005
Electricity consumption from domestic renewable sources	A voluntary “sense of Congress” goal to provide 25% by 2025.	EISA 2007
Net-zero energy	25 zero-net-energy installations by 2025; All Federal buildings designed after 2020 achieve zero-net-energy.	EO 13514
Non-tactical vehicle (NTV) fuel consumption	Reduce 2% annually through 2015, 20% total by 2015 using a 2005 baseline; 30% reduction by 2020.	EO 13423 & EO 13514
Fossil fuel use in new/renovated buildings	Reduce 55% by 2010; 100% by 2030 relative to 2003 level.	EISA 2007
Hot water in new/renovated buildings from solar power	At least 30% of hot water demand in new or substantially modified Federal building must be met using solar hot water heating by 2015, if lifecycle cost effective.	EISA 2007
Non-petroleum fueled vehicles use (ethanol, natural gas)	Increase by 10% annually until 100% of fleet is fueled by non-petroleum based fuel.	EO 13423
Energy metering for improved energy management	Meter electricity by October 2012 and meter natural gas & steam by October 2016.	EPAct 2005 & EISA 2007

*Source: Office of the Deputy Assistant Secretary of the Army for Energy and Partnerships (2009).

The DSB task force (2008) identified the movement of fuel from the point of procurement to the point of use as a “grave energy risk” for the DOD. Today’s military operations require a large amount of fuel and ensuring convoy safety and fuel delivery requires a tremendous show of force. Soldiers in Afghanistan today carry more than 26 pounds of batteries in their packs to power global positioning system (GPS), communication systems, and other combat equipment (Tyson 2009). The military uses fuel for more than mobility. In fact, one of the most significant consumer of fuel are installations—containing communications infrastructure, living quarters, administrative areas, eating facilities, and industrial activities necessary to maintain mission activities. All of these activities require electricity. Electricity from a grid that utilities report is increasing unreliable.

In August 2003, 50 million people living in the Northeast, Midwest, and Ontario were suddenly left in the dark when their electric power failed. More than 500 generating units at 265 power plants shut down—a quiet collapse cascading across the landscape. Most homes and businesses regained power within a day (though some plants took 2 weeks to regain full capacity), a quick restoration that was possible primarily because no significant equipment was damaged. Still, critical national security systems

failed. U.S. border check systems were not fully operational, causing a severe backup of truck traffic on our northern boundary. There were related effects from the outage as well. Water and sewage plants shut down. Gas stations stopped working, and rail service was curtailed. Many cellular phone providers, radio stations, and television stations lost service—their backup power systems were insufficient. The trigger for this massive blackout was tragically simple: an Ohio utility had failed to properly trim trees near a power line (Hendricks 2009, USEPA 2004).

The North American Electric Reliability Corporation and the DSB (along with other organizations) project the increasing incidence of electrical interruptions caused by mechanical shortcomings and extreme weather conditions, resulting from both inadequately sized backup power and climate change. The U.S. Global Change Research Program's report on U.S. Climate Change Impacts (USGCRP 2009) describes the impacts of climate change trends on energy:

- Warming will be accompanied by decreases in demand for heating energy and increases in demand for cooling energy. The latter will result in significant increases in electricity use and higher peak demand in most regions.
- Energy production is likely to be constrained by rising temperatures and limited water supplies in many regions.
- Energy production and delivery systems are exposed to sea-level rise and extreme weather events in vulnerable regions.
- Climate change is likely to affect some renewable energy sources across the nation, such as hydropower production in regions subject to changing patterns of precipitation or snowmelt.

By simply focusing on global warming without thinking of other possibilities, the U.S. military could miss other contingencies. The United Nations' International Panel on Climate Change has noted that different regions will experience climate change differently. Some regions will warm while others cool, and even the occurrence and intensity of storm events will differ from region to locality. The engineering tolerances of weapons systems, for example, are made within known limits. So as the climate and weather patterns change, military equipment and training might have to adapt. One potential scenario, for example, could be that the engines of combat vehicles may fail to start because of a frozen fuel line as a result of biofuel's high water content.

The roadmap for the future of energy security includes unifying a more centralized and coordinated approach to dealing with core security issues. Topics of efficiency, source diversification, infrastructure, technology innovations, financing, and environmental protection will be driving conversations among a variety of stakeholders.

There are also significant opportunities for installation utility cost savings through improved utility contracting and better understanding and management of utility contracts. Many installation Directorates of Contracting (DOCs) are reluctant to consider changes to their utility contracts that would be advantageous to the Government because of the high costs associated with utility contracts exceeding their warrants, or simply due to a lack of understanding of utility contracting—they are afraid they will make a mistake. Many installation DOCs operate in a vacuum and fail to draw on other garrisons' experience. Installation legal staffs often present another roadblock to optimization of utility contracting and contract management. Again, the issue usually stems from a lack of experience and expertise in the area of utility contracting. Developing a team of Contracting Officers and lawyers with utility contracting experience and expertise would be an invaluable consulting resource for installation DOCs and legal staffs to reduce the mystique surrounding utility contracting.

More attention must be given to efficient and effective management and oversight of existing installation utility contracts. Too often, the people responsible for approving utility invoices and reselling utilities to garrison tenants view this task as "another duty as assigned." DPW Energy Managers are pressured to "Go Green," use Energy Savings Performance Contracts (ESPCs), reduce energy, etc. As a result, management of utilities services does not get the attention it deserves. Proper staffing and training of the people who manage utility contracts on a day-to-day basis has the potential to realize significant cost savings.

Finally, retention of Energy Managers is often dependent on compensation compared to what other organizations are paying for the same (or lesser) responsibilities. Traditionally, GS-13/14 represents management roles within the Army. The typical grade for an Army Energy Manager is GS-11/12. However, in 2007, the U.S. Department of Veterans Affairs (VA) started an energy program (VA 2007). The VA classified the majority of their hospital energy manager positions GS-13 and GS-14. Very soon after, some Army energy managers left Army positions for VA positions. As competition in private industry also grows, private-sector employees are

earning higher average salaries than their public-sector colleagues. The result can be a shortage of experienced personnel in the Army for these types of energy manager positions. As energy management continues to be a significant focus not just for the Army but for all sectors of society, the Army may be at a disadvantage in attracting and retaining personnel. The Installation Management Command will need a strategy to ensure that skilled and capable personnel will be serving installation energy management needs.

5 Scenarios

A hypothetical installation faced with a set of two scenarios serves to illustrate possible outcomes from different course of action. This "thought exercise" will explore the concept of developing planning scenarios for real installations, similar to the National Planning Scenarios (DHS 2006) maintained by the Department of Homeland Security as part of the National Preparedness Guidelines (DHSD 2007).

The scenarios are intended to be generally applicable. They focus on response capabilities and needs, not threat-based prevention activities. They include: (1) loss of the electrical power grid and (2) loss of petroleum products, such as natural gas and liquid fuels. These scenarios and their variations have widely varying probabilities of actually occurring, but unlikely events do occur and the Army's installations must be ready. The analyses of these scenarios are intended to highlight actions/investments that are most critical to address energy security, and actions/investments that may be important (but less critical) in these crises situations. IMCOM may also benefit from an improved understanding of how regional circumstances may change courses of action from one installation to another, and also how these circumstances may help IMCOM prioritize actions/investments in light of constrained budgets.

Scenario 1: Electric power grid disruption

Scenario overview/probable causes

In this scenario, disruption of the commercial grid is considered in both the short and long-term timeframe. The assumed cause of a short-term outage (minutes to hours) is a reduction in power line voltage, commonly known as a "brown-out." Extreme overloads caused by heavy air conditioning and refrigeration equipment usage taxes the electrical distribution system to the point where a brown-out state exists over much of the power company's distribution network. Long-term disruption (days to weeks) is the assumed result of line and component loss caused by extreme storm events (i.e., hurricane, thunderstorm, tornado, etc.), or by human-caused events (e.g., cyber or explosive attack).

Short-term Disruption. Short duration outages are most probable during high demand times (i.e., hot summer days) when the sum of regional gen-

eration and transmitted power imported from nearby sub-transmission systems may not be sufficient to meet the regional demand. Typically, short-term commercial power outages result from impacted local distribution infrastructure (systems less than 34kV). Loss or failure of local distribution component(s), local act of sabotage, local switch/recloser trip or over current condition, distribution substation hardware failure, etc. can all lead to brown-out situations. Impacted devices can include power factor corrective capacitive elements, metering, fuses, relays, overhead switches, distribution level VAR regulators, etc.

Brown-outs. It is possible that in the next 5 to 10 years utility providers will struggle with electrical delivery. The industry has projected a significant loss in capacity margins by 2017 for most of North America (NERC 2008). California, Rocky Mountain, Southeast, and Central regions remain areas of concern, but the Desert Southwest remains the area of most concern. Here, summer peak demands are exacerbated by increasing temperatures and population growth. The Desert Southwest is projected to fall below recommended capacity margins as soon as 2010.

Capacity margins are measurements of the bulk power system's ability to supply the aggregate electric power and energy requirements of electricity consumers. Higher capacity margins indicate that the system is more capable of withstanding extreme weather, and of forecasting errors, system events, and unscheduled resource outages. Lower capacity margins can lead to reduced reliability. Those regions where capacity margins are projected to fall below NERC's Reference Margin Levels in the next few years need to add resources quickly to maintain bulk power system reliability (Figure 6). (Appendix A lists at-risk installations.) Stimulus funding, changes in resource categorization, establishment of forward capacity markets, or the addition of new resources may improve this outlook.

Temperature increases are another common distribution stress. In the summer heat wave of 2006, for example, electric power transformers failed in several areas (including St. Louis, MO, and Queens, NY) due to high temperatures, causing interruptions of electric power supply. The number of incidents caused by extreme weather has increased tenfold since 1992 (Figure 5). The portion of all events that are caused by weather-related phenomena has more than tripled from about 20 percent in the early 1990s to about 65 percent in recent years.

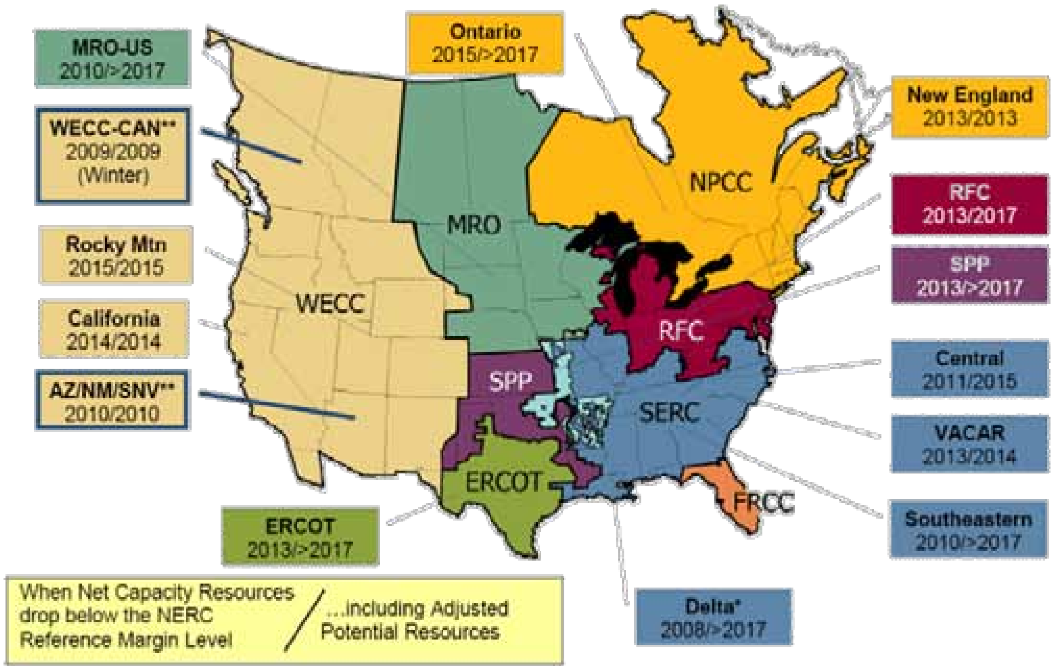


Figure 6. Net electrical capacity compared to the North American Electricity Reliability Council's (NERC's) reference margin level (NERC 2008).

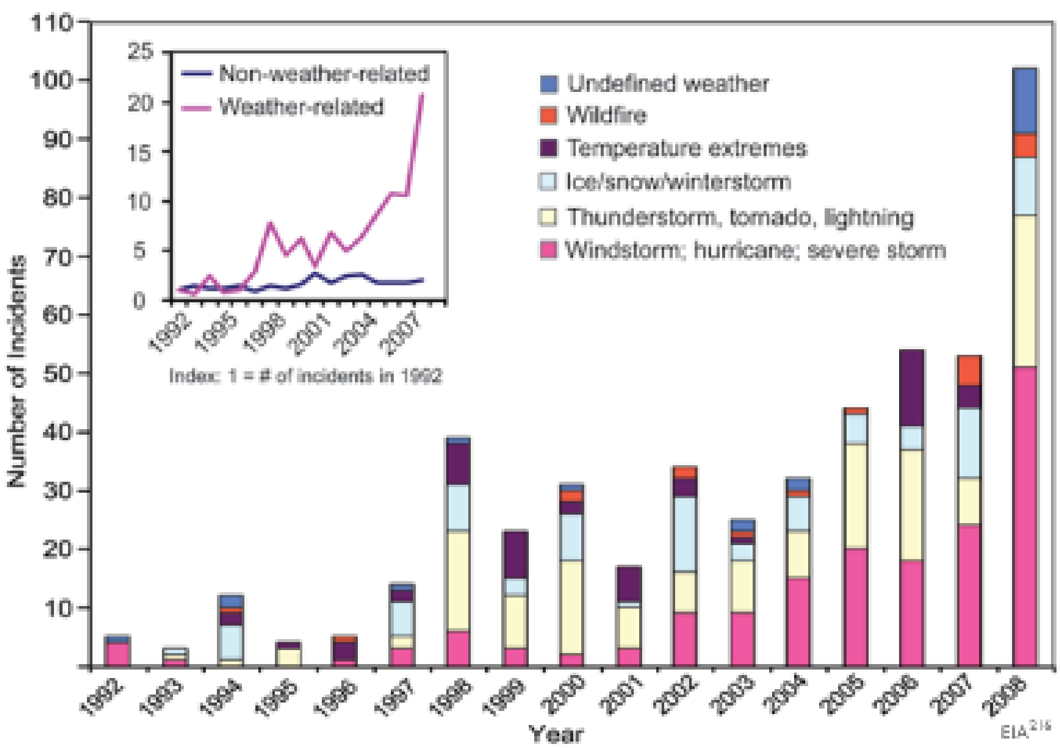


Figure 7. Significant weather-related U.S. electric grid disturbances (EIA 2009).

Weather-related events (including droughts and associated increased susceptibility of vegetation to wildfires) are more severe, with an average of about 180,000 customers affected per event compared to about 100,000 for non-weather-related events (and 50,000 excluding the massive blackout of August 2003). The data shown in Figure 7 include disturbances that occurred on the nation's large-scale "bulk" electric transmission systems. Most outages occur in local distribution networks and are not included in the graph. Although Figure 7 does not demonstrate a cause-effect relationship between climate change and grid disruption, it does suggest that weather and climate extremes often have important effects on grid disruptions. In fact, more frequent weather and climate extremes are likely in the future, which poses unknown new risks for the electric grid (USGCRP 2009).

Long-term Disruption. Typically, long-term commercial power outages result from catastrophic or cascading impact to regional transmission infrastructure (greater than 132kV) such as major "bottleneck" components at generation stations, along the commercial transmission system, or the point of main electrical service to the installation. Loss or failure of regional transmission component(s), organized acts of sabotage, transmission substation hardware failure (including capacitive voltage controllers, reactors and static VAR compensators and phase shifting transformers, large commercial step down transformers), etc. can all lead to long-term outages (Schumacher 2006). Impact to these components results in long duration events because HV transmission level components are often custom made, built-to-order devices with long lead times for both service and replacement. In addition, many commercial electric service providers only retain a limited contingency inventory of critical infrastructure components. Even a relatively mild storm event that impacts multiple delivery points along the sub-transmission system can exhaust the commercial utility company's inventory of "long lead time" components and affect any single or multiple grid components.

Major Storms. Extreme weather events have become more common in recent years and this trend is expected to continue in the future (Solomon 2007). Rising global temperatures lead to increased frequency of hurricanes, stronger cyclones, and a global shift in the frequency and duration of floods, droughts, and heavy precipitation events. Although climate change will affect different regions in different ways, it is generally expected that weather-related grid disturbances are a challenge for strategic planning and risk management. The most familiar example is effects of se-

vere weather events on power lines, such as from ice storms, thunderstorms, and hurricanes.

Future Disruption Considerations. As a result of the networked nature of a smart grid, which is anticipated to be integrated into the grid during the next 5 to 10 years, a sophisticated cyber-attack could happen anywhere and emerge from anywhere, including compromised computer systems owned by civilians, industry, internationally, or from within the military's network. A cyber-attack could affect any single or multiple grid components resulting in either short- or long-term disruptions. A deliberate, sophisticated cyber-attack would plausibly result in a large scale, catastrophic grid outage since virtually every transmission and distribution component, generation station, and power conversion device along the transmission has some level of microprocessor-based "intelligence" and network interface for monitoring system status.

Mitigation/response considerations

Short-term Disruption. Common effects of brown-outs include electronic equipment functioning poorly—or not at all. Errors, due to erratic power supply, may creep into computer operations. Motors will overheat. Some motor types will slow down. Increased electrical interference will affect computer and communication operations. Reasonable courses of action to mitigate the threat and impact of a brownout scenario include involving DPW/installation utility system personnel, installation vulnerability and emergency planning sessions antiterrorism/force protection (AT/FP) personnel, and other appropriate directorates (whenever possible) in threat assessment. This may allow system maintenance personnel (government-owned, government operated [GOGO] systems) to learn about potential targeted regions or vulnerabilities of the distribution infrastructure and reinforce these components via upgrade and redundancy.

Brown-out combat is mostly a case of planning ahead. Once the brown-out is in progress, about all one can do is observe the effects. It is safe to assume that most regions will experience brown-out conditions several times per year—some unlucky regions may suffer brown-outs monthly or daily. A minimum prevention measure is to ensure that all critical electronic and computing equipment is adequately equipped with high performance interference filters and spike suppressors. Installations could invest in both local generation resources and inverters/interconnection switchgear (inside the installation boundary) that could minimize mission impact. These investments could be coupled with demand savings technologies (e.g.,

light emitting diode (LED) lighting, active occupancy sensors for HVAC and lighting, energy efficient construction, off-peak chillers, storage, etc.). To mitigate frequent short-term outages, installations may also consider investment in small, mobile engine-driven generators and Uninterruptible Power Supply (UPS) systems to protect both sensitive electronic loads and other mission critical (e.g., command and control) operations. This would allow allocation of energy dynamically to meet the critical demand as they change or emerge. Optimal short-term energy storage solutions (cf. Figure 5) include flywheels, battery-based UPS systems, supercapacitors, etc.

Long-term Disruption. Effects from a major storm event that destroys both lines and components both outside and inside the installation boundary might cause a long-term power outage condition as many commercial critical infrastructure components (typically 132 kV and above) have long lead times for both service and replacement (Schumacher 2006). In addition, many commercial electric service providers only retain a limited contingency inventory of critical infrastructure components, including step down transformers, power factor corrective capacitive elements, metering, fuses, relays, overhead switches, etc. Even a relatively mild storm event may exhaust the limited utility inventory of components. In addition, availability of trained personnel for onsite HV electrical maintenance will be critical to the installation to restore its training/preparedness. If the installation distribution system is GOCO, the contractor's ability to secure sufficient trained HV personnel may become critical. If several areas of the transmission system are affected, a restoration plan to include well-defined restoration phases may be appropriate. Such a plan could be designed to avoid potentially damaging voltage/frequency swings when additional generation/loads are connected to the local grid during the restoration process.

Combating long-term disruptions is a case of combined planning and technology investments. Possible courses of action to mitigate the impact of a major storm event include identifying continuity of operations and restoration plans to include well-defined phases. Such plans could be designed to avoid potentially damaging voltage/frequency swings when additional generation/loads are connected to the local grid during the restoration process, and to identify potential targeted regions or vulnerabilities of the transmission infrastructure and reinforce these components through upgrade and redundancy. Because long-term outage events can often be traced to HV infrastructure failure, the installation may take steps to ensure availability of trained HV electrical maintenance personnel. Optimal

long-term energy storage solutions (Figure 5) include large fuel cell installations, flow batteries, wind and PV systems, large engine-driven generators, fixed and mobile generators with larger fuel reserve capacity, etc. These assets can deliver long-term ride-through capability and can interface with automatic transfer switches at building electrical service. Automatic transfer switches installed at facility electrical service points allow the installation to allocate energy dynamically to meet the critical demands as they change or emerge. This affords the installation the ability to operate from a total energy systems efficiency perspective in terms of both electrical and fuel resources, management of energy operations, and continuity of operations and coordination of stakeholders. Further development of tools and technologies that allow installations to diversity power sources will be critical to overcoming the effects of long-term disruptions.

Scenario 2: Natural gas/petroleum disruption

Scenario overview/probable causes

In this scenario, natural gas and petroleum disruptions are considered under a short- and long-term timeframe. Unlike the nation's electrical grid, there are a small number of major natural gas transmission lines leading form regions rich in resources (e.g., the Gulf of Mexico) to areas without large supplies (e.g., the upper Midwest and New England). Although buried, these pipelines are very long and difficult to defend. There are also large above- and underground storage fields distributed around the nation that serve mainly to buffer seasonal demand. Natural gas is pumped to these storage fields during periods of low demand (summer), and then extracted from the fields during periods of high demand (winter). The assumed cause of a short-term outage (minutes to hours) is a fracture in one or more natural gas distribution lines or mains in an area near the installation. Long-term disruption (days to weeks) is the assumed to be the result of loss of regional gas transmission line(s) or production loss caused by extreme storm events (i.e., hurricane, thunderstorm, tornado, etc.) or human-caused events. Modern utility systems are connected in interdependent networks in which each component may provide a vital service to another, the failure of one utility may often cascade to other systems. For example, an installation may generate some of its own electricity with natural gas engines, pump a portion of its water from wells using electric pumps, use steam absorption chillers, and produce compressed air from a mixture of electric and gas engine compressors. A disruption of natural gas may adversely impact on-installation generation of electricity, steam, and

curtail the production of compressed air since these systems depend directly on natural gas as their prime mover.

Short-term Disruption. Natural gas moves via distribution lines or "mains" with diameters that range from 2 in. to more than 24 in. Within each distribution system, separate sections operate at different pressures, with regulators controlling the pressure. Some regulators are remotely controlled by the utility to change pressures in parts of the system to optimize efficiency. By raising and lowering the pressure on any pipeline segment, a pipeline company can use a given distribution segment to store or buffer gas during periods when there is less demand. This practice, referred to as "linepacking," allows pipeline operators to handle hourly fluctuations in demand very efficiently. Monitors also control fuel movement. Large transmission lines for natural gas can be compared to the nation's interstate highway system for cars. Large amounts of natural gas are moved thousands of miles from the producing regions to local distribution companies (LDCs). Natural gas moves through the transmission system at up to 30 miles per hour, so it takes several days for gas from Texas to arrive at a utility receipt point in the Northeast. Local utilities have gate stations that receive gas at many different locations and from several different pipelines.

Typically, short-term commercial gas outages result from impacted local distribution infrastructure (with operating pressures less than 200 psi) and can be a consequence of natural disaster (e.g., including flood, landslide, earthquake, etc.) that can lead to gas distribution line fracture and failure. Digging is also a typical cause for distribution line failure and gas leak. Most natural gas distribution systems run under streets and walkways, and are only visible above ground at major interconnection points, service points, meter reading areas, etc. Fractured lines can cause unsafe conditions including potential fire. Short duration outages have most severe impact during cold winter days as many installations rely on natural gas and fuel oil to heat facilities and run boilers. In some cases, this dependence is reduced if boilers can be driven with either gas or fuel oil depending on availability of supply.

State-to-state variation in incident rates exists, suggesting context-specific risks that should be investigated. Hazardous liquid accidents have higher expectance rates in California, Delaware, Hawaii, Kansas, Massachusetts, New Jersey, and Oklahoma. Natural gas transmission accidents are more frequent in Alaska, California, Louisiana, Massachusetts, Mississippi, New

Jersey, Oklahoma, Texas, and West Virginia. Natural gas distribution accidents are most frequent in Alaska, D.C., Louisiana, Maryland, Maine, Missouri, Pennsylvania, Texas, and Vermont (Zimmerman 2008).

Long-term Disruption. Typically, long-term natural gas outages result from catastrophic or cascading impact to the bulk high-pressure transmission systems (200-1500 psi). A gathering supply point or main compressor station may need one or more field compressors to move the gas to the pipeline or the processing plant. Each of these compressors is machine driven by an ice based system with custom-designed hardware and feeds steel pipe systems with diameters ranging from 20 to 42 in. Even a relatively mild storm event that impacts multiple pressurizing and delivery points can result in large scale gas outage. Petroleum transmission pipelines may suffer similar failures in transmission, storage, and production facilities. Moreover, petroleum and natural gas line failures tend to be affected by other infrastructure disruptions. Failures within the transportation network (shipping, rail, and trucking) might result in long-term power outage conditions.

Major Storm. For this scenario, the recent events of Hurricane Katrina will frame an example situation. The high winds and storm surge associated with Hurricane Katrina halted all oil and gas production from the Gulf—disrupting nearly 20 percent of the nation's refinery capacity, and closed many oil and gas pipelines (CBO Testimony 2005). Storm events destroyed more than 100 platforms and damaged 558 pipelines. Power companies took up to 2 months to provide power to large portions of the service area. Roadways and bridges required significant repair before response crews could access the damage. Gasoline was severely limited for the first week following the disaster. Communication systems (i.e., telephone, radios, and cellular systems) gradually recovered within the first week.

Mitigation/response considerations

Short-term Disruption. Short-term loss of natural gas affects the functioning of electrical equipment, computer, and communication operations. Restoration process and event response actions may include line repressurization, reset meters, and reset flow valves in the affected areas. Reasonable courses of action to mitigate the threat and impact of short-term outages include involving DPW/installation utility system personnel, installation vulnerability and emergency planning sessions with AT/FP and other appropriate directorates (whenever possible) in threat assess-

ment. This may allow system maintenance personnel (GOGO systems) to learn about potential targeted regions or vulnerabilities of the distribution infrastructure and reinforce these components through upgrade and redundancy. It may be especially vital for personnel to be familiar with the facilities/processes that depend on fuel oil delivery or natural gas supply at a given minimum supply pressure. In addition, automatic monitoring equipment can identify affected areas of the gas distribution and isolate them by closing main gas shut-off valves. Installation of large bulk fuel storage units will also help ride through time when gas and fuel supplies are limited.

Similar to short-term electrical outages, combat strategies for short-term fuel outage is mostly a case of planning ahead. The best prevention measure is a well rehearsed tactical strategy. Greater technological efficiency can give installations more options and reduce vulnerability, yet the minimum prevention measure is an effective strategy to ensure all critical equipment is adequately backed-up.

Long-term Disruption. Just as fuel line failures are affected by other infrastructure disruptions, to a greater extent, long-term fuel disruptions affect other infrastructure. Fuel lines are part of a highly connected and interdependent infrastructure that provides essential services such as water/waste, communications, transportation, and emergency services.

Possible courses of action to mitigate the impact of a long-term outage are similar to a short-term outage—identify continuity of operations and restoration plans and invest in long-term energy storage. Optimal long-term energy storage solutions (Figure 5) include large bulk fuel storage tanks, pressure monitoring equipment, multiple points of entry for fuel transport vehicles, etc. Long-term outage combat strategies must, however, include a greater understanding of the interdependencies among critical infrastructure. The continuity, sustainability, and resiliency of each infrastructure component must be understood by utility, communication, transportation, and emergency service provider alike. Many energy managers are generally prepared for short-term local and regional responses; however, long-term disruption requires a much broader response. Future investments in a system-wide approach are needed to improve system robustness, redundancy, and rapid recovery. Additionally, new technologies and behavioral changes focused on reduction and increased efficiency are necessary.

6 Conclusion and Recommendations

Army leadership has recognized and embraced the importance of improving energy security for installations, as evidenced by AESIS and an ambitious set of goals. However, the means to achieve these goals, both policy and technology based, are less clear. This chapter sets forth actionable enterprise-level recommendations for consideration. Energy Security is a complex issue, with rapidly evolving technology providing new opportunities to help address challenges, but with these new technologies come new energy security threats, vulnerabilities, and risks. Because many of the environmental factors impacting energy security (technology, regulation, material availability, economic markets, threats) change rapidly – these recommendations will need to be frequently reviewed and updated, even though this work has attempted to look at the mid- and long-term issues associated with energy security. Figure 8 summarizes the recommendations in a "roadmap" view to help impart a sense of timing.

Near term (2010-2015)

- **Radically improve facility energy efficiency.** Renewable energy projects currently receive the lion's share of attention. Barring a revolutionary breakthrough in power generation technology, however, achievement of the number of Net Zero Energy installations will, in large part, rely on reducing facility loads. It is feasible to begin to move to a 65 percent reduction in Federal energy usage compared to ASHRAE 90.1, beyond the 30 percent requirement of EISA 2007. Use working relationships with DOE and FEMP to support technologies that represent good enterprise solutions—including ECMs for existing buildings and new construction.
  Explore each technology curve more fully. From a strategic posture point for view, investing in ultra-efficient windows would be an adoption posture, lighting investments would represent early adoption, and smart microgrid investments would represent a shaping posture.
- ***Plan for distributed power.*** The electrical power network is changing. DOE is reworking the national commercial grid through the National Smart Grid project, while demonstration projects using microgrids proliferate. Manpower and cyber aspects of a more highly automated National Smart Grid pose a potential threat to installation energy security. Establish an Integrated Process Team that will work with DOE, NETCOM, the Defense Information Systems Agency

(DISA), and USACE to address interoperability and cyber-security implications posed by smart and microgrids to reduce avoidable risks and cross-organizational protocol.

- ***Adopt open source/open standard network security protocols through NIST and the DOE.*** Security flaws and vulnerabilities within proprietary systems cannot stay hidden for any significant length of time. History has shown that open source and open standard security protocols, such as Internet Protocol Security (IPsec) and Advanced Encryption Standard (AES) have become more secure due to their availability for peer review (Cisco Systems Inc. 2009). Supporting the use of open source and open standard instead of proprietary systems will enhance the security of DOD power grids.
- ***Evaluate installation energy projects on clustered supply/load analysis.*** It is common to consider energy projects facility by facility. However, a more optimal solution can often be achieved by considering geographically grouped "cluster" of facilities with complementary load schedules and energy production capability. This can lead to more efficient boiler use, heat extraction from grey water (low exergy approaches), or cluster-sized combined heat and power plants. Extend the clustered analysis approach to installation-wide analysis and require it for renewable energy projects (biomass, waste-to-energy, wind, and solar (photovoltaic and thermal).
- **Exercise energy security capabilities.** Use exercises and gaming to test installation energy security strategies under challenging and realistic scenarios. Establish and exercise energy security working groups at national, regional, and installation levels. Adopt more stringent resiliency planning scenarios as per DSB recommendations. For instance, plan for loss of the commercial grid for up to 6 months. Support a greater understanding of the interconnected relationships among energy security, infrastructure, and environmental conditions.
- **Increase involvement in Defense (Defense Critical Infrastructure Program [DCIP]) and Army Critical Infrastructure Programs (Critical Infrastructure Risk Management [CIRM]).** IMCOM is not an official "Asset Owner" for many approved Task Critical Assets, yet they are frequently tenants on IMCOM installations. As such, IMCOM is responsible for providing supporting critical infrastructure. Task Critical Asset lists are classified, so energy managers without a clearance are often not aware of their importance. To alleviate this problem, increase synergy between the energy security and critical infrastructure programs (DCIP & CIRM). Obtain SECRET or better clearances for energy managers and ensure that they become

familiar with DCIP methods used to identify and mitigate vulnerabilities. Ensure that the proper system upgrades, maintenance, and backups are provided for critical infrastructure.

- ***Prioritize installations.*** Establish a prioritized and classified list of critical installations based on weighted criteria such as approved Task Critical Assets, electrical capacity at-risk regions, and importance to Army Force Generation. Use this list as a factor in selection of energy security projects.
- ***Establish a central repository of energy infrastructure data.*** Generally, installations mange their own energy and utility systems. Given the decentralized management, it is difficult to research, develop, and implement comprehensive energy-related programs and long-term strategies. A centralized repository of garrison utility maps and other critical data would ease dissemination of vital information for energy security studies, audits, and regional outage recovery plans.
- ***Develop new investment funding strategies.*** The difficulty of obtaining funding for energy projects is arguably the most difficult and risk-prone barrier to achieving energy security. The three sources most often used are Federal funding (e.g., Military Construction, Army [MCA] Energy Conservation Investment Program [ECIP]), energy services contracts, and enhanced use leases. Establish a study group to identify potential new funding mechanisms and the actions needed to put them in place.
- ***Establish a team of utility contracting experts.*** Identify contracting officers and legal staff with expertise and experience in utility contracting that can provide consulting support to installations and their legal staffs. Provide training and continuing education opportunities for contracting officers and legal staff on the basics of utility contracting, evolving regulatory requirements, and opportunities.
- ***Properly staff and train personnel who manage utility contracts and utility sales.*** There are numerous opportunities for installations to save money on their utilities. Many of these are quite simple, but easily overlooked (e.g., questioning sales taxes, avoiding late fees, and getting reimbursement from tenants). With proper training and staffing of these activities, many installations could realize significant utility cost savings.
- ***Remain competitive in terms of employee compensation.*** It takes well trained staff to execute the energy projects needed to meet the goals. High turnover and vacant positions put the Army at a disadvantage. As the private economy strengthens, the Army must review its current grade and office structure to remain competitive.

- ***Foster partnerships.*** Effective partnerships can help navigate through complex challenges. Having the "right" agreements and understandings in place between Federal agencies, local utilities, and financial institutions can result in fewer hurdles to achieving energy security. Examine the status of agreements between installations and local utility providers as a factor in assessing energy security.

Medium term (2015-2025)

- ***Establish a contractor certification/qualification program for ultra-efficient facilities.*** General contractors and even many Energy Services Contractors are often unfamiliar with construction practices for advanced energy conservation technologies. Therefore, they overbid to mitigate risk. Working with appropriate government agencies and industry groups, establish an education and qualification program that would establish preferred providers of energy efficient construction vendors for facilities and power systems.
- ***Adopt a regional approach to energy security planning.*** Some energy security options are simply too large to be considered on an installation-by-installation basis. Identify installations that are geographically close to other DOD and government agencies' sites. Seek partnerships that identify economy of scale opportunities for secure power generation plants or for additional power redundancy.
- ***Establish standardized analytical tools.*** As the *Army Energy and Water Campaign Plan for Installations* states, energy security is often a cost obligation. If installations are to increase energy security, standardized metrics and methods should be established to help installations expand energy security plans to include annual updates, progress monitoring, and proposed projects for energy security improvement. Metrics must be consistent with what emerges from the AESIS.
- ***Conduct an installation scale nuclear power generation demonstration.*** Although nuclear power has been considered off limits for decades, emerging technologies such as the Hyperion Power Module (HPM) represent small scale, modular power generation devices that could provide both thermal (70MWt) and/or electrical (25MWe) sources that are well matched for powering critical loads at many installations.
- ***Pursue enhanced contracting mechanisms for energy security.*** The MCA program, energy services contracts, energy conservation improvement program, and enhanced use leasing programs are all legacy programs that were developed for particular purposes. Energy security often has somewhat different goals than energy conservation

programs and these legacy programs are not optimized for the kind of systems thinking required for energy security. Require new contracting mechanisms be authorized that are optimized for energy security contracting.

- ***Establish an Energy Security Enhancement Fund.*** Leverage large revenue streams potentially available from development of utility scale renewable projects on Army land to invest in energy security initiatives.

Long term (2025 +)

- ***Develop an "Islands of Stability" concept for installations.*** Installations are often called up to provide civil support during natural disasters, civil unrest, and times of war. The DSB made a case for creating a long-term energy self-sufficiency capability for installations of up to 6 months. In the event of large scale and long-term failure of the national infrastructure, installations could serve as service providers, safe havens, and rebuilding islands for the nation.
- ***Seek More Flexible Cost-Sharing Options.*** While the enhanced use leasing arrangement provides a means for Army installations to make land and other assets available to private firms for production of energy – this alone is not always sufficient to secure investments, especially investments that provide targeted results for improving the energy security on Army installations. Arrangements that provide for some "cost sharing" might allow for more highly targeted outcomes that benefit the military, and would also ensure that military installations have more oversight, if applicable, of the planning and operations of these energy resources. Cost-sharing could also involve profit-sharing – allowing installations to "retain" savings and reinvest into future energy security initiatives.
- ***Work with industry to develop, test and field "evolving" systems.*** Current solar panels have low conversion efficiencies, and there are many investments being made now towards improving these efficiencies. If, in 10-20 years, new solar panels (or a new solar technology) are available with 2-3 times the efficiency – then military installations, even those that are early technology adopters, will want a path to "evolve" their systems without major investments to convert their existing infrastructure to the new, more efficient systems. Similar issues exist with other energy technologies. To limit the costs and impacts of evolving technologies, large "buyers" like military installations should work with industry on renewable energy, microgrid, and other energy "systems" approaches that easily adapt to technology advances.

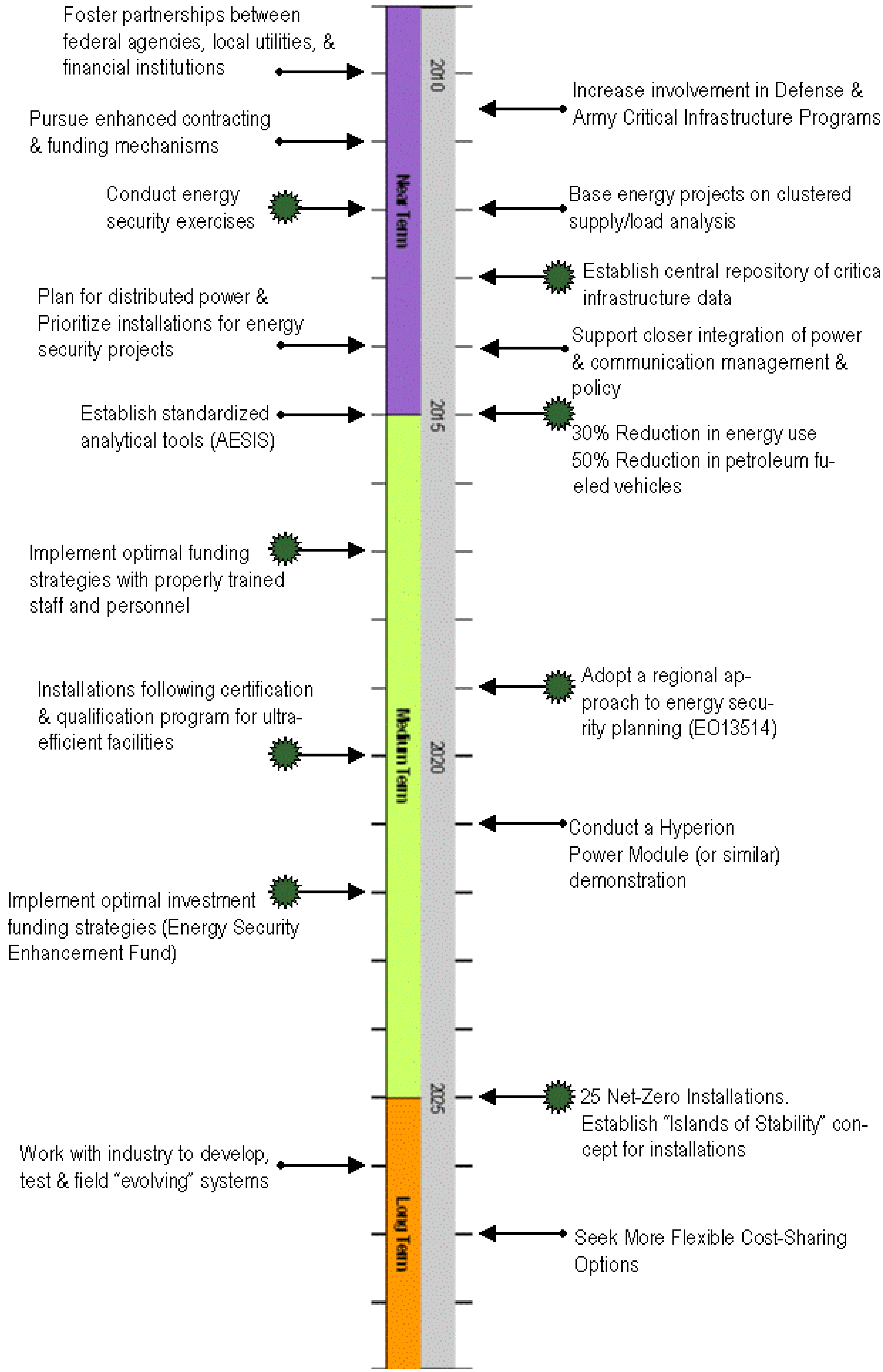


Figure 8. Recommended installation energy security roadmap.

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Acronyms and Abbreviations

Term	Spellout
24/7	24 hours a day, 7 days a week
ACSIM	Assistant Chief of Staff for Installation Management
AEPI	Army Environmental Policy Institute
AES	Advanced Encryption Standard
AESIS	Army Energy Security Implementation Strategy
AMI	Advanced Metering Infrastructure
ANSI	American National Standards Institute
ARNG	Army National Guard
ASHRAE	American Society of Heating, Refrigerating, and Air-Conditioning Engineers
AT/FP	Antiterrorism/Force Protection
AVN	Aviation
CBO	Congressional Budget Office
CCS	Carbon Capture and Sequestration
CCT	Correlated Color Temperature
CEERD	U.S. Army Corps of Engineers, Engineer Research and Development Center
CERL	Construction Engineering Research Laboratory
cfm	Cubic Feet per Minute
CIRM	Critical Infrastructure Risk Management
CO	Carbon Monoxide
CO2	Carbon Dioxide
CONUS	Continental United States
CRI	Color Rendering Index
DASA	Deputy Assistant Secretary of the Army
DC	District of Columbia
DCIP	Defense Critical Infrastructure Program
DER	Distributed Energy Resources
DISA	Defense Information Systems Agency
DOAS	Dedicated Outdoor Air System
DOC	Directorate of Contracting
DOD	U.S. Department of Defense
DOE	U.S. Department of Energy
DPW	Directorate of Public Works
DSB	Defense Science Board
E&P	Energy and Partnership
ECIP	Energy Conservation Investment Program
ECM	Energy Conservation Measure
ECO	Energy Conservation Opportunity (ECO)
EEAP	Engineering Energy Analysis Program

Term	Spellout
EIA	Energy Information Administration
EISA	U.S. Energy Independence and Security Act of 2007
EO	Executive Order
EPA	Environmental Protection Agency
EPACT	Energy Policy Act (of 2005)
EPRI	Electric Power Research Institute
EPS	Expanded Polystyrene
ERDC	Engineer Research and Development Center
ESPC	Energy Savings Performance Contract
EUL	Enhanced Use Lease
FAC	Facility
FEMP	Federal Energy Management Program
FERC	Federal Energy Regulatory Commission
FY	Fiscal Year
GHG	Greenhouse Gas
GOCO	Government Owed, Contractor-Operated
GOGO	Government-Owned, Government-Operated
GPS	Global Positioning System
HPM	Hyperion Power Module
HQ	Headquarters
HSPD	Homeland Security Presidential Directive
HV	Heating and Ventilating
HVAC	Heating, Ventilating, and Air-conditioning
IAQ	Indoor Air Quality
IMCOM	Installation Management Command
IPCC	Intergovernmental Panel on Climate Change
IPsec	Internet Protocol Security
IT	Information Technology
K	Kelvin
kV	Thousand Volts
LDC	Local Distribution Company
LED	Light Emitting Diode
LTA	Logistics Transformation Agency
MCA	Military Construction, Army
mK	Meter Degree Kelvin
MTA	Military Training Area
MWt	Megawatt
NERC	North American Electricity Reliability Council
NETCOM	Network Energy Technology Command
NIST	National Institute of Standards and Technology
NOx	Nitrogen Oxide
NSN	National Supply Number

Term	Spellout
NTV	Non-Tactical Vehicle
O&M	Operations and Maintenance
OCONUS/CONUS	Outside Continental United States/Continental United States
OMB	Office of Management and Budget
ORC	Organic Rankine Cycle
pa	Pascal
PHEV	Plug-in Hybrid Electric Vehicle
PMU	Phasor Measurement Units
PO	Post Office
psi	Pound per Square Inch
PV	Photovoltaic
R&D	Research and Development
S/P	Scotopic to Photopic [ratio] (S/P)
SEC	Army Senior Energy Council
sq ft	Square Feet
T&D	transport and dispersion
TD	Technical Director
TR	Technical Report
U.S.	United States
UMCS	Utility Monitoring and Control System
UPS	Uninterruptible Power Supply
URL	Universal Resource Locator
USACE	U.S. Army Corps of Engineers
USAFA	U.S. Air Force Academy
USGCRP	U.S. Global Change Research Program
VA	U.S. Department of Veterans Affairs
VAR	Volt Ampere Reactive
W	Watt
WAATS	Western Army National Guard Aviation Training Site
WWW	World Wide Web

Appendix A: Electrical Capacity Margins

Listed below are Army installations of greatest concern for electrical resource capacity margins—regions expected to exceed capacity margins by 2010.

Desert Southwest

Albuquerque Logistics Transformation Agency (LTA)
Black Mountain
Buckeye Training Site
Camel Tracks Training Site
Camp Luna
Camp Navajo
Casa Grande Training Site
De Bremond Training Center
Dona Ana Range Camp
Douglas Training Site
Florence Military Reservation
Floyd Edsal Training Center
Fort Bliss
Fort Huachuca
Fort Wingate Missile Launch Complex
Onate Training Site
Papago Park Military Reservation
Picacho Training Site
Rio Rancho
Rittenhouse Training Site
Safford Training Site
Tucumcari Training Site
Western ARNG Aviation (WAATS) Silverbell
White Sands Missile Range
Yuma Proving Ground

Pacific Northwest

Beaver Training Area
Biak Training Center
Blanding Armory
Buhl Training Site
Camp Adair
Camp Murray
Camp Rilea
Camp Seven Mile
Camp Williams
Camp Withycombe
Deseret Chemical Depot
Dugway Proving Ground
Edgemeade
Fort Harrison
Fort Lewis
Fort William Henry Harrison
Gowen Field and Orchard Range
Green River Launch Complex
Hawthorne Army Depot
Hayden Lake LTA
Hayford Pit LTA
Idaho Falls Training Site
Idaho Launch Complex
Kelly Canyon Training Site
Limestone Hills Training Area
Ogden Local Training Area
Pocatello Airport LTA
Pocatello Training Site
Poverty Flats Training Area
Price Training Area
Sierra Army Depot
St. Anthony Training Site
St. George Training Area
Stead FAC MTA
Tooele Army Depot
Twin Falls Training Site
Umatilla Chemical Depot
Vail Tree Farm LTA
Vernal Training Area
Waco Training Area
Weyerhaeuser AVN Training Area
Yakima Training Center

Appendix B: ERDC/CERL Energy Efforts

The following list of recent (2007 to present) efforts made by ERDC/CERL's Energy Branch provides a "snapshot" of current projects to inform the enterprise-level, strategic viewpoint:

- Utilities Modernization Program
- IMCOM Building Automation Systems Plan
- Building Automation System Implementation Website
- Energy Advisor Development and Installation Showcase Demonstration
- Army Boiler Inventory Database
- Review & Recommendations for Flagship Program Projects
- Implementation of Best Practices in Army Barracks Renovation, Repair, and New Construction Projects
- Army Energy Performance Benchmarking
- Energy Audits
- Energy Conservation Opportunities (ECOs) Scoping Study for outside continental United States/Continental United States (OCONUS/CONUS) Army Installations
- Energy Use Reduction and Mold Control in Barracks
- Energy Conservation & Mold Prevention Project Reviews
- Engineering Energy Analysis Program (EEAP) Technical Support
- Fort Stewart Barracks Dehumidification
- 2009 HQ IMCOM Energy Summit IV
- Energy Design Guidance & Checklists for Army Garrisons
- Utility Monitoring and Control System (UMCS) Manager Scoping Study.

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14. ABSTRACT
Over the past decade, the U.S. Army has invested significant resources to ensure sufficient and sustainable supplies of energy, which is essential to mission performance. Many forward-looking energy projects are ongoing today as a result of this investment. To continue this success, a team of energy experts (composed of energy, engineering, and program management experts from U.S. Army Corps of Engineers [USACE], Assistant Chief of Staff for Installation Management [ACSIM], Installation Management Command [IMCOM], U.S. Air Force Academy, and private consultants) was formed to take a broad, strategic, and forward-minded look at evolving conditions and to explore the investments that are most critical to address energy security. The analysis looked at the technologies and policies driving future energy production, conservation, and security. The team then explored two hypothetical situations to illustrate possible outcomes from different courses of action. These scenarios included: (1) loss of the electrical power grid, and (2) loss of petroleum products, such as natural gas and liquid fuels. The result was a set of system-wide actions that IMCOM may choose to implement to improve energy security.

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CASI, energy, security, sustainable facilities

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